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MANUFACTURE OF HOKE PRECISION GAGES AT THE BUREAU OF STANDARDS

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Here is the first published account of the manufacture of precision-gage blocks at the U. S. Bureau of Standards. This process up to now has been considered a military secret. Gage blocks are being produced at the bureau with an accuracy limit of a few millionths of an inch.

OF PARTICULAR interest to mechanics, manufacturers and engineers is the development and perfection of a commercial manufacturing process for making precision gages to within an accuracy of a few millionths of an inch. Fig. 1 shows one of the several sets of precision gages which have been completed at the Bureau of Standards. The gages are of cylindrical cross-section rather than of rectangular cross-section, for the reason that greater wearing surface is secured, additional application for direct measurements are possible and, furthermore, the cylindrical gage is more economically manufactured. The qualities of these flat end gages which permit their being wrung together and built up, as shown in Fig. 2, is quite generally understood. It is apparent that the cylindrical gages may be readily wrung from any direction and, therefore, the wear tends to be more uniform than with oblong shape where the blocks are wrung from the ends.

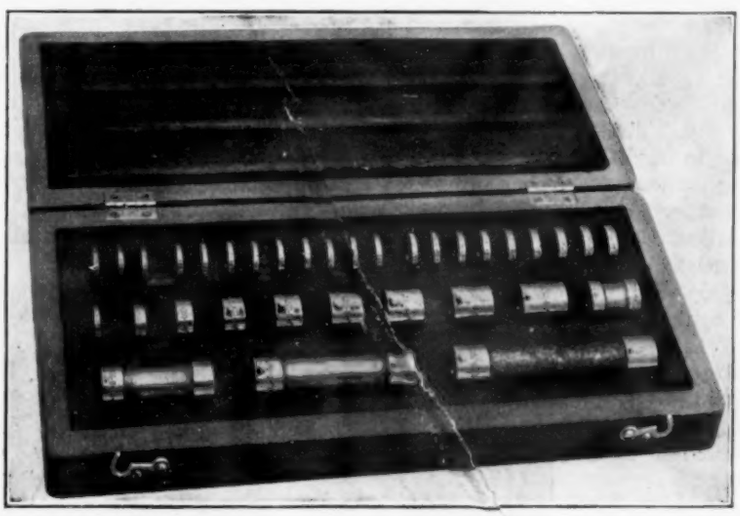

FIG. 1. A TYPICAL SET OF PRECISION GAGE BLOCKS MADE AT THE U. S. BUREAU OF STANDARDS

When it is considered that these gages are being produced to within five-millionths of an inch (0.000005 in.) for length, flatness and parallelism of end surfaces, and that the development of the process of their commercial manufacture has taken place in a period of about six months, the achievements represented in the development of the manufacturing process will be realized. In the Hoke gages manufactured at the Bureau of Standards, the unit of measure has been one-millionth of an inch (0.000001 in.). While it is comparatively easy to produce blocks the surfaces of which are flat and parallel within 0.000001 in. or 0.000002 in., it is more difficult to retain the absolute length within this amount owing to the variation in the material, temperature conditions, and conditions in the abradants used. However, with special care, gages can be produced accurate in length to within 0.000001 in. or 0.000002 in. As a commercial product, gages which are accurate to within 0.000005 in. are of more than the required accuracy.

One of the investigators of this problem was Mr. William E. Hoke of St. Louis, Mo., who began experimenting and studying the production of these blocks about four years ago. Like many other similar problems, impetus was given by the needs of the government and American manufacturers in carrying out this program for producing munitions during the recent war.

In a letter under date of May 4, 1918, Mr. Hoke advised the Bureau of Standards that he had, after spending about three years in experimental work, de-

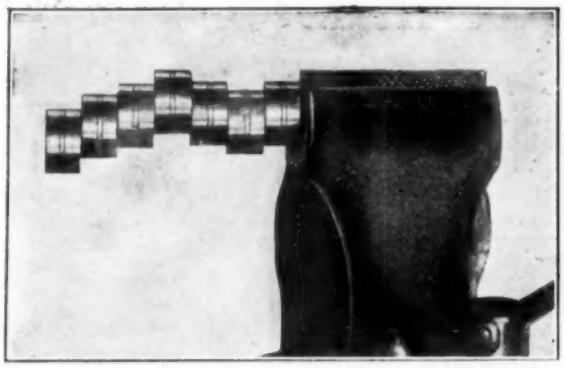

FIG. 2. A NUMBER OF "HOKE" GAGE BLOCKS WRUNG TOGETHER

vised a method for producing gage pieces in quantity for a system of gages similar in principle and use to the Johansson or Swedish gages but entirely different in form. This matter came to the attention of the writer, with the result that in a letter of May 15 it was suggested that sample blocks be submitted to the Bureau of Standards for investigation and, if possible, a conference be arranged. In a subsequent letter of June 17, an invitation was extended to Mr. Hoke to visit the Bureau of Standards as the bureau was equipped to be of service in the way of perfecting the manufacture and test of the gages in the shop organized by the gage section. As a result of this invitation work was immediately started on the design of an experimental machine for demonstrating the manufacture of gages of the required accuracy.

During the period that the experimental machine was being developed at the Bureau of Standards, the utility of the invention for the use of the War Department was being considered. The patents branch, contract section, procurement division, forwarded the description of the device through military channels to Lieut.-Col. E. C. Peck, gage section, engineering division, Ordnance Department. As a result of this investigation by the War Department, Colonel Peck on July 8 reported that the invention looked feasible and suggested that a sum of money be provided to equip a shop for the manufacture of these gages and for the use of the government inspectors. On July 20, the operation of the preliminary machine was demonstrated to Colonel Peck. In a letter under date of July 22, it was stated that 0.112-in. samples were produced of the same length within 0.000002 in. and with flat surface within 0.000004 in. at 20 deg. C. measuring 0.112008 in. On Aug. 8, an allotment of $50,000 was set aside to cover the cost of the work to be done by the gage section of the Bureau of Standards. The work was immediately started to secure the necessary machine tools and other equipment for producing the gage blanks and for performing the various finishing operations. Experimental work was also initiated in connection with the various problems to be solved, such as, proper material, heat-treatment, finish, permanency and measurement. Up to Feb. 1, 1919, there have been produced at the Bureau of Standards in the neighborhood of 1700 gages which are accurate in flatness, parallelism and dimension within about 0.000005 in. This has been accomplished in spite of the fact that the delivery of the machine tools required for the production of the gages was considerably delayed, the complete equipment not being available until about Dec. 15; and also in spite of the fact that it was necessary to overcome many difficulties arising in connection with securing the proper steel, heat-treatment, seasoning and in securing the proper degree of finish on the gages. The full coöperation extended by Dr. S. W. Stratton, Director of the Bureau of Standards and the advice extended by Lieut.-Col. E. C. Peck, Ordnance Department, on many problems arising in the manufacture of the gages, has made it possible to overcome the many difficulties and realize success at an early date in the undertaking. The experimental work in developing the manufacture has been carried out entirely at the Bureau of Standards under the supervision of the gage section. In this experimental work, Major Hoke, representing the gage section of the engineering bureau, Ordnance Department, and Mr. H. N. Mercer of the gage section of the Bureau of Standards have contributed very largely towards the success of the development. The measurement of the gages by the light wave interference method was worked out and applied by Mr. C. G. Peters of the optical division, Bureau of Standards.

MANUFACTURE

One of the first problems which arose in the manufacture of the gages was the selection of a suitable material. An analysis of the conditions to be fulfilled is shown in the following list, which gives the qualities of the material desired in order of their importance: 1. Suitable coefficient of expansion. 2. Permanency. 3. Wearing qualities. 4. Resistance to corrosion. 5. Susceptibility to high polish. 6. Ease of machining. 7. Uniformity of material.

In the selection of a suitable material, many possi-

FIG. 3. MARKING THE GAGE BLOCKS IS SHOWN AT THE LEFT. AT THE RIGHT THE OUTSIDE DIAMETERS ARE BEING GROUND

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bilities such as, agate, fused quartz, stellite, invar, packhardened machine steel and tool steel, were given careful consideration. Agate, fused quartz, stellite and invar may be eliminated, owing to the fact that their coefficients of expansion differ very materially from that of steel. While invar was suggested on account of the fact that it does not expand when heated or cooled or, in other words, under ideal conditions has a coefficient of expansion of zero, it is in reality least suitable of any of the previously mentioned materials for use in making precision gages. In practically every case these precision gages are used for verifying or measuring other gages which are of steel or pieces and parts made of steel. If it is desired to ascertain the length of a gage or part at a standard temperature of 68 deg. F. and a standard made of invar was used, it will be necessary that the measurement be made exactly at the standard temperature or that the temperature be recorded and a correction made for the amount the gage expanded or contracted from the standard temperature of 68 deg. F. to the temperature at which it was measured. In the case of the steel gage being measured with the invar standard, the gage should and the invar standard does not expand. If, however, the standard is of steel it expands the same amount as the steel gage being measured and the measurement can be made at any temperature.

STEEL RECOMMENDED BY METALLURGICAL DIVISION

	Johansson	Bureau of Standards	Material Used
Carbon	1.19%	1.00% to 1.25%	0.99%
Chromium	1.23%	1.00% to 1.50%	1.47%
Manganese	0.11%	Not more than 0.20%	0.35%
Silicon	0.24%	0.15% to 0.25%	0.24%
Nickel	0.39%	0.25% to 0.50%	None
Phosphorus	0.026%	As low as possible and less than 0.03%	0.012%
Sulphur	0.012%	As low as possible and less than 0.03%	0.026%

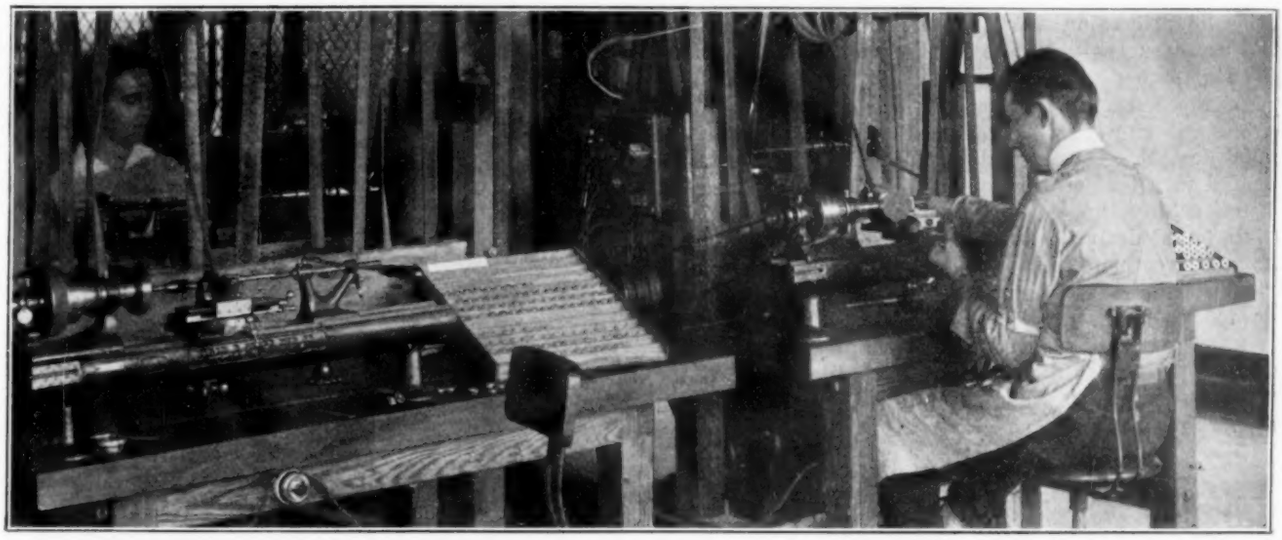


FIG. 4. AT THE RIGHT THE OPERATOR IS GRINDING THE EDGE RADIUS. THE PRECISION LATHE AT THE LEFT IS RIGGED FOR LAPPING THE COUNTERSINK

Recommendations of Metallurgical Division

The use of packhardened machine steel as a material for precision gages, was eliminated, owing to the fact that it was believed that after manufacture the soft core would tend to change differently than the hard shell. This has been verified by experiment to some extent, but is still under further investigation. The problem then being restricted to the use of tool steel, it remained to determine which grade and composition of tool steel would best suit the purpose. After making chemical analyses of Swedish gages, and after giving careful consideration to the qualities desired, a steel was suggested by one metallurgical division of the Bureau of Standards, having a chemical composition as indicated in the following table. The steel used corresponded as closely as possible to the recommendations of the metallurgical division with the exception of the nickel content which, as specified, was non-essential.

It will be noted that the carbon content of from 1.00 to 1.25 per cent. corresponds to the regular tool-steel carbon content. The chromium content of from 1.00 to 1.50 per cent. is essential for its qualities in preventing corrosion; for its beneficial effect on the wearing qualities and, also, on the reduction of warping or change during hardness. The percentage of nickel from 0.25 to 0.50 per cent. is not enough to be of material benefit in preventing corrosion and the absence of nickel in the material used makes but little difference. The content of the other elements specified corresponds closely to a good grade of tool steel.

Schedule of Operations

The various operations required for producing finished gages are listed in the following table:

Number of Operation	Description of Operation	Machine Used
1	Stock	
2	Turn, drill, ream, countersink one side, cut off	Cleveland automatic
3	Rough grind the cut-off side	Blanchard vertical surface grinding machine
4	Countersink the cut-off side	Drill press
5	Mark size	Dwight-Slate marking machine
6	Heat-treat	Hardening room
7	Rough grind faces	Blanchard vertical surface grinding machine
8	Season	Hardening room
9	Finish grind radius on edges	Sloan & Chase lathe
10	Rough lap	Hoke lapping machine
11	Inspect	
12	Lap countersink, both sides	Sloan & Chase bench lathe
13	Finish outside diameter	No. 10 Brown & Sharpe cylindrical grinding machine and on walrus hide buff
14	Finish lap faces	Hoke lapping machine
15	Final inspection and measurement	Optical laboratory
16	Assemble in sets	
17	Pack and ship	

Machining Rough Blanks.—The rough blanks are machined from 1-in. annealed bar stock with a Cleveland automatic screw machine. In this operation the blanks

are turned to $\frac{3}{4}$ in. diameter; $\frac{3}{16}$-in. hole is drilled and reamed through the center of the blank; a 90-deg. countersink, having a diameter of $\frac{1}{4}$ in. on the finished face, is put in one face of the gage; it is chamfered on both edges with a pronounced radius; it is then cut off to the required thickness. The machining is complete in this operation with the exception of putting a countersink in the cutoff face.

In the next operation, the cutoff face of the gage is rough-ground on the Blanchard surface grinding machine, and the gage is brought down in thickness to within about 0.010 in. above the finished size. This operation facilitates the next operation, No. 4; namely, countersinking the cutoff side, which is done with an ordinary drill press.

In operation No. 5, the dimension of the gage and other identification marks are rolled in the edge with the use of a Dwight-Slate marking machine, as shown in Fig. 3.

In the hardening operation, No. 6, the gages are preheated slowly to a temperature of from 800 to 1000 deg. F. They are then placed in a lead pot and heated to a temperature of from 1550 to 1569 deg. F. In quenching the gages from this temperature, it has been found desirable to quench into water through oil as this treatment results in gages which are of sufficient hardness (the resulting hardness ranging from 90 to 95 deg. scleroscope scale) and the number of cracked gages is reduced to a minimum. It has been found best to use different depth of oil on top of the water tank, using a greater depth of oil for long gages than for short gages.

Rough-Grinding Faces

In operation No. 7, rough-grinding the faces, which is done on the Blanchard surface grinder, the gages are brought down to within about 0.005 in. of the finished size, care being taken to grind each face an approximately equal amount in order to have the countersinks of equal depth at each face of the gage. In the rough-grinding with the Blanchard Surface Grinder, a soft wheel and an excess of water is used in order to eliminate as far as possible surface cracks which might develop in the grinding operation.

In operation No. 8, the gages are given a seasoning treatment, which consists of dipping them alternately in boiling water and ice water about 30 times. The gages are held in the boiling water and in the ice water only for a sufficient period to insure that the pieces have reached the temperature of the boiling water or ice-water bath. In connection with the seasoning treatment, it will be mentioned that experiments carried out in which the gages were dipped alternately in boiling water and liquid air, show that the gage undergoes a very pronounced change in size and shape during the first two or three cycles but that after seven or eight cycles they remain practically constant. In the seasoning treatment with boiling water and ice water the same changes occur but a larger number of cycles are required for the seasoning process.

In operation No. 9, the radius on the edges is finished by grinding. This is accomplished on a Sloan & Chase bench lathe, as shown at the right in Fig. 4. In this operation, any burrs on the edges of the blanks which might scratch the laps used in subsequent operations, are removed.

In operation No. 10, the gage blanks are rough-lapped on the Hoke lapping machine. In the rough-lapping, a coarse abradant is used and the lapping proceeds quite rapidly. Only about 60 minutes' lapping is required to reduce a batch of 50 gages from about 0.002 in. oversize to 0.0005 in. oversize.

In operation No. 11, after the rough-lapping operation, the gages are inspected for any fine surface cracks which may have developed during the hardening or grinding. For this inspection a very sensitive test was discovered, which is of particular interest on account of its simplicity. In this test for cracks the gages are immersed in coal oil which has in suspension fine steel particles resulting from the lapping process. The gages are then removed and the steel or iron particles arrange themselves in the magnetic field, emanating from the cracks, with the result that a very pronounced streak of black iron particles indicates the fine crack which would not be discovered with the naked eye or even with the use of a magnifying glass or microscope.

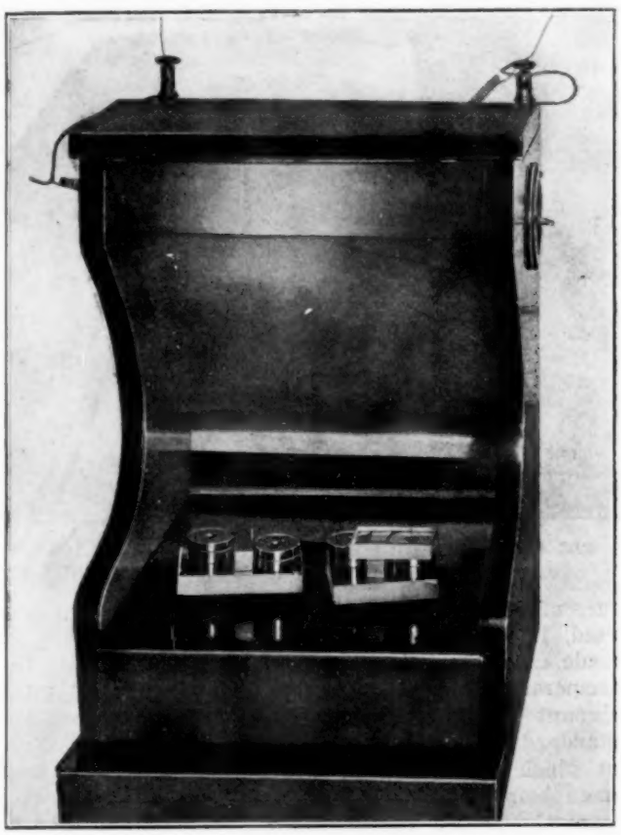


FIG. 5. APPARATUS USED IN TESTING FLATNESS AND PARALLELISM TO ONE MILLIONTH OF AN INCH

In operation No. 12, the gages which pass inspection are prepared for final lapping, in that the countersink is finished by lapping. This is performed on a Sloan & Chase bench-lathe outfit, as shown at the left in Fig. 4. In this rig the gage is held in a split chuck and the countersink is lapped by a copper lap charged with emery, the copper lap having the form of the countersink and being given a movement back and forth from the center line of the work at an angle of 45 deg. with the face of the gage. This movement produces a 90-deg. countersink and tends to hold the shape of the lap at its proper form.

In operation No. 13, the outside diameter of the gage is finished by buffing, or by grinding and buffing; the

shorter gages are finished by buffing only, while the longer ones are ground to true them up prior to buffing. When the gages are ground on the outside diameter, a Brown & Sharpe No. 10 cylindrical grinding machine as shown in Fig. 3 is used.

The finish-lapping of the gages (operation No. 14) is done on the Hoke lapping machine. While it requires no particular skill, it must be executed under careful supervision and a definite procedure must be followed, in order to insure that the gages are lapped to proper size, and of a suitable finish. In this operation about 50 gages are lapped in an operating time of about two hours. In the reduction of the gages to the proper size, it is necessary to keep the supply of abradant constant, the speed of the machine constant, and as far as possible all conditions uniform, in order that the lapping may proceed at a uniform rate. The gages are measured from time to time, the rate determined, and are gradually brought down to the required size within 0.000005 in. In many instances

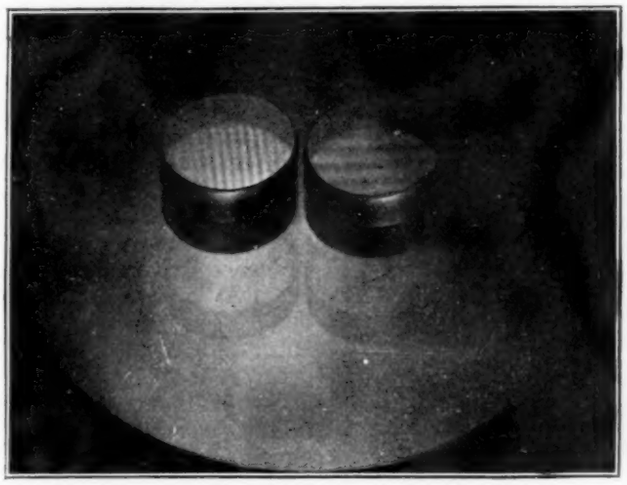


FIG. 6. PHOTOGRAPHIC ILLUSTRATION OF THE INTERFERENCE METHOD, SHOWING LIGHT WAVE LINES

gages are produced in which nearly all the gage pieces are correct in length within 0.000001 in. or 0.000002 in. For instance of a batch of 53 gages of nominal dimension 0.1005 in., 31 were absolutely correct to the sixth decimal place (measured 0.100500 in.) and the others were within 0.000001 in. or 0.000002 in. of the correct size.

The final inspection listed under operation No. 15 is made in the optical laboratory with the use of the light wave interference method. Fig. 5 shows the only apparatus required for making direct comparisons of length for testing the flatness and parallelism of the end surfaces to within 0.000001 in. This apparatus includes only two optical glass flats and a source of light of one color. In Fig. 5 the gages mounted between the glass flats are ready for comparison by examining the interference waves resulting from light reflected from the ground glass placed above the gages at an angle of 45 deg. and reflecting the rays of light emitted from a vacuum tube containing helium gas. Instead of a light from a helium tube, there could be substituted a light from a mercury-vapor lamp, such as known commercially as the Cooper-Hewitt lamp. The use of a source of light of one color, such as a helium tube or a mercury-vapor lamp, is not necessary in the light wave interference method. Either daylight or artificial light may be used, but in this case the interference bands resulting are made up of several colors merging into one another, while with the use of a light of one color, the interference bands take the form of more definite light and dark spaces or bands, which facilitate the inspection.

In the complete determination of the accuracy of the gages by the light wave interference method, the following procedure has been adopted:

1. Select from a batch of gages to be measured, one nearly perfect in flatness and parallelism of end faces.
2. Determine its absolute length by the light wave interference method.
3. Compare the remainder of the batch of gages with length of standard previously determined.

The determination of the absolute length of a block by the light wave interference method while not difficult or tedious, is not explained here in detail for the reason that it involves rather a complicated computation. Briefly, the process consists of wringing two glass plates on each end of the gage and with suitable apparatus determine the number of light waves between the gage planes. Inasmuch as the exact number of light waves in a length represented by the international standard meter has been determined to within an accuracy of about one part in 15 million, the length of a light wave is very definitely known and is constant. Therefore, the determination of a number of light waves between the two glass planes on each end of the gage is equivalent to determining its exact length to a high degree of accuracy. The comparison of the length of a gage with a standard and the determination of the flatness and parallelism of the end faces is very easily accomplished with the apparatus as shown in Fig. 5.

Light Wave Interference Method

The principle utilized in the light wave interference method will be explained with reference to Fig. 6. Here, two circular glass flats are shown in contact with a larger glass flat, and the interference bands resulting from interference of the light reflected from the bottom surface of the upper flat and from the top surface of the lower flat, are in the form of straight lines. The fact that the interference bands are straight indicate that the two reflecting surfaces are flat. If the one surface was flat and the other surface convex or concave, the bands would assume the form of concentric circles.

It will be noted that the reflection of the interference bands resulting from one of the glass flats are at right angles to the interference bands resulting from the other glass flat. This is due to the fact that the air between the upper glass flats and the lower glass flat is in the form of a wedge, the point of the wedge on the other case. The bands resulting from the wedge of air between the two surfaces indicate both the position of the wedge and the magnitude of the taper. In the glass flat at the left, the bands are relatively close together. This flat indicates that the taper of the wedge of air is relatively steep. The fact is that each interference band shows that the surface of the upper glass flat at this point is approximately 0.00001 in. higher than the point on the surface corresponding to the preceding band. Thus on the small flat at the left, 13 interference bands may be counted, which indicates that the edge of the top flat shown at the left, near the center of the figure, is approximately 0.00013 in. higher or lower than the edge at the left of the figure. In a similar manner, the four bands shown in

the flat at the right indicates that the edge of this flat near the observer is 0.00004 in. higher or lower than the edge away from the observer. Were one of the small upper flats to be brought into absolute contact with the lower flat the interference bands would disappear.

Thus, it will be seen that from the shape of the bands, the character of the surface as to whether it is flat, spherical, concave, convex or of other complicated form, can be determined, and furthermore, that from the distance between the interference bands, the amount that the surface deviates from a plane can be determined. In reality the interference bands may be likened to a contour map where irregular lines show elevations at intervals of 10 or 100 ft. as may be the scale of the map. In the comparison of a number of gages of the same nominal size with a standard, generally two gages are compared at once with a known standard as shown in Fig. 5. The latter illustrates the use of a previously standardized Swedish gage as a standard for comparing two gages which are placed at each side of the Swedish gage. All three gages are wrung on the lower optical flat using a drop of alcohol which results in bringing the gages in practically absolute contact with the glass flat eliminating all air. Another glass plate optically flat is laid on top of the gages and by noting the character and direction of the interference bands on all three gages, it can be ascertained at a glance whether the gages are longer or shorter than the standard and the amount of such difference; whether the surfaces of the gages are flat, and in addition, whether or not they are parallel to the bottom surface of the gages. The entire process of comparing gages with a standard by the light wave interference method is extremely simple and the cost of the measurement and inspection including the determination of the standard for each size gage is in the neighborhood of about seven cents per gage. Considering the commercial value of these gages and the accuracy with which they are measured, this cost of inspection is indeed very slight.

Application of Gages

The gages are used to advantage for surface plate work. The cylinders, being provided with a hole and countersink in the center, after being run together, can be securely fastened by a rod and turnbuckle through the center hole, the flat head screws of the rod and turnbuckle being below the measuring surface. This results in a standard which is in the shape of a rod and is very convenient for general use. If in wringing the gages together they are slightly out of line, they can be aligned very readily by simply rolling them on a flat surface. Spherical end pieces are provided which can be securely fastened by means of a turnbuckle, and with these end pieces the gages are applicable for the measurement of depths of holes or for such work as measuring the rifling lands and the grooves of cannon. In reality, the cylindrical shape is applicable for the measurements for which the rectangular-shaped gages are used and in addition has other advantages.

While the development of the process of manufacturing Hoke precision gages was undertaken and accomplished at the Bureau of Standards in collaboration with the engineering division, Ordnance Department, as a war activity, the advantages to be gained by American manufacturers is of equal and perhaps of more importance than the advantages which would perhaps have accrued had the program for procuring war material continued. The program for the manufacture of these gages called for a production of 50 sets for the use of the Ordnance Department, and it is of interest to know that 10 sets were available Mar. 1, 1919, and that the program is to be complete and the 50 sets available in the near future. The government has secured shop rights for manufacturing these gages, using the machine and process invented by Major Hoke. Since the manufacturing equipment is available at the Bureau of Standards, there should be no difficulty in having available sufficient gages of this character which might be required by government departments for future military preparations.

The outcome of this work of the gage section, Bureau of Standards, has thoroughly demonstrated and proven that precision gages of the utmost accuracy can be produced in this country.

NO illustration of the Hoke lapping machine is reproduced at this time because of the fact that Mr. Hoke's patents have not yet been issued. The general construction and operation of this device is as follows:

The work is done on a lapping fixture driven by a vertical drilling machine. The fixture consists of three plates. The lower and upper plates are lapping plates and are approximately 18 in. in diameter and 4 in. thick. The intermediate plate is the gage block carrier. This is of somewhat less thickness than the gage blocks which are to be produced and has holes near its circumference which carry the gage blocks and which allows both surfaces of the gage blocks to come in contact with the lapping surfaces. The upper and lower lapping plates are secured against rotation, the sole rotary movement being that of the gage-block carrier plate which rotates and oscillates at the same time. The upper lapping plate, however, is free to descend and approach the lower plate as lapping of the gages proceeds.

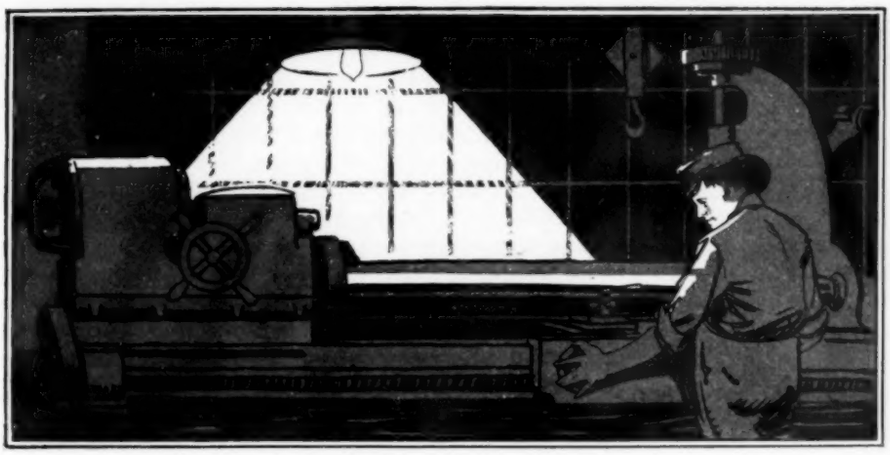
A method of equalizing the thickness of the gage blocks has been worked out. It consists of transposing these blocks diametrically and at 90° at various times during the process of lapping each batch. The rate of removal of metal has been carefully timed by experience, and a clock operating on the stop watch principle is used to indicate the progress of lapping. When the clock indicates the approach of completion, the gages are measured and, if necessary, placed back for further lapping for a time period determined upon, according to the amount of metal still to be removed.—EDITOR.

Knurling With a File

BY A. W. GARRETT

Having occasion at one time to knurl the head of a very small screw, and fearing that to use a knurling tool in the toolpost in the regular way would bend or break the piece, I sought another means of doing the work.

Running the lathe at a moderate speed and standing behind it, I pressed a new mill file on the part to be knurled, letting the file drift along with the work so that no cutting took place. By this method the sharp teeth of the new file sank into the soft metal sufficiently to leave a very good knurled appearance.



LIGHT, ELECTRICITY and The Shop

By C. E. Clewell

Motor Capacity for Shop Machinery

In this article the heating effect of the electric current in its relation to the limit of motor capacity is discussed. The single value of current equivalent to the varying demands of a machine tool on its driving motor is explained. A number of methods are described whereby such a single value of current may be found by experiment under actual operating conditions. These methods include the use of the watt-hour meter, oil calorimeter and the graphic ammeter. A comparatively recent development on the oil-calorimeter principle in the form of a so-called "root-mean-square" meter is described and its method of use treated.

IN ORDER to point out practical schemes for checking up the sizes of motors in terms of the loads to which they may be connected or for a determination of the size of a motor for a new machine certain fundamental principles of motor operation and of the heating effect of a varying current should be known. The purpose, therefore, is to include in the preliminary part of this article a brief discussion of these principles and then show how they may be applied under practical operating conditions.

The satisfactory operation of a motor involves a number of points, chief of which are that it shall comply in operation with approved limitations in the following respects: Operating temperature, mechanical strength, commutation, dielectric strength, insulation resistance, efficiency, power factor and regulation[1]. Practically all of these points except the first are fixed by the design of the machine, so that under shop conditions the primary attention is often given to the temperature at which the motor operates as an indication of how nearly it is suited to the load with which it is connected.

The rules referred to above state, in effect, that the capacity of a motor, so far as it relates to temperature, is usually limited by the maximum temperature at which the materials in the machine, and especially those used for insulating purposes, may be operated for long periods without deterioration. When this safe limit is exceeded deterioration is rapid and increases

[1]This statement and a portion of the notes immediately following are based on the standardization rules of the American Institute of Electrical Engineers.

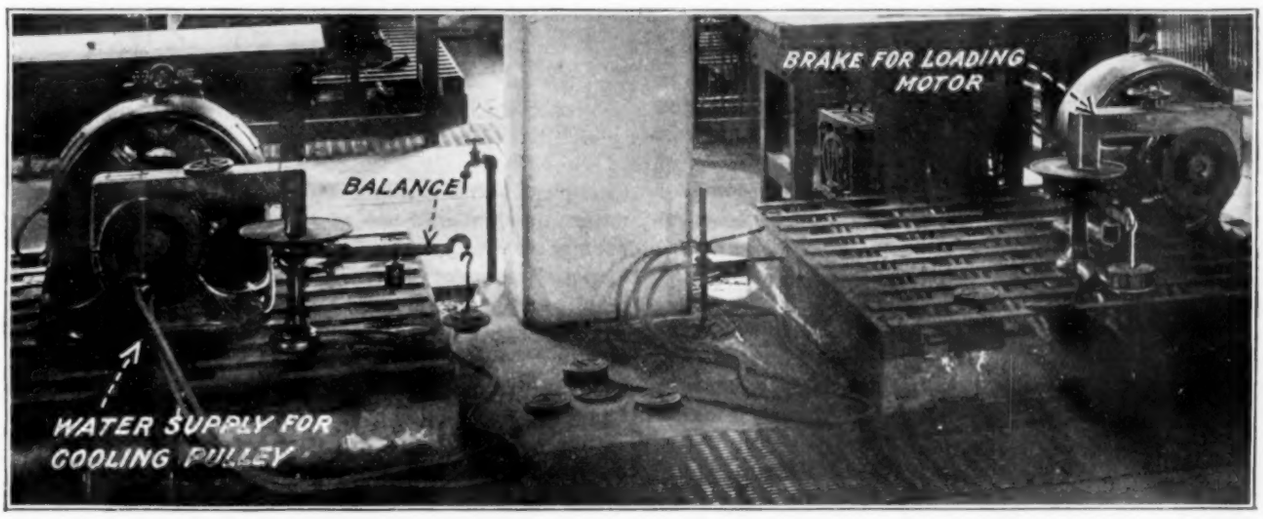


FIG. 1. A LABORATORY METHOD FOR TESTING MOTORS

with the length of time that the excess temperature is maintained, as well as with the degree of this excess, and in the end the insulation may break down and thus disable the motor completely.

On the other hand there does not seem to be any gain in the operation of a motor at temperatures below the safe limits so far as the insulation life is concerned. Hence we may conclude that while care should be exercised to keep the load on a motor from rising to values which will make it operate too hot, it is good practice to operate it at such loads as will keep its temperature within the limits set by good practice. To illustrate the values of these temperature limits it may be stated that the standardization rules of the A. I. E. E. assign a maximum temperature to which the material may be subjected of 105 deg. C. for cotton, silk, paper and similar materials when so treated or impregnated as to increase the thermal limit, or when permanently immersed in oil; this also applies to enameled wire. A figure of 125 deg. C. is given for mica, asbestos and certain other materials under given conditions.

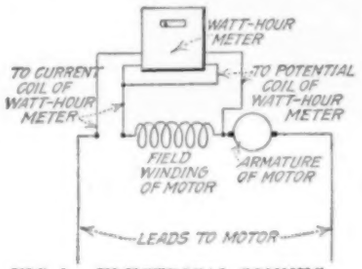

WATT-HOUR METER
TO CURRENT COIL OF WATT-HOUR METER
TO POTENTIAL COIL OF WATT-HOUR METER
FIELD WINDING OF MOTOR
ARMATURE OF MOTOR
LEADS TO MOTOR

FIG. 2. ELECTRICAL CONNECTIONS FOR A WATT-HOUR METER

From what has been stated the rating of a motor as given on the name plate of the machine has or should have taken into account the temperature limits given above, and it is customary in handling shop motors to use the name-plate rating as the guide for the permissible output which may safely be placed on the unit. The difficulty of assigning such motors to machine tools is usually due to variation of the power required by the machine throughout some particular cycle of duty. Thus the current may have one value for several minutes, quite another value for a succeeding period, may be at rest for still another period, and so on. Some of these current values may be above the limits set by the name plate of the motor; others may be below. Our purpose is, therefore, to ascertain what single value of current is equivalent in its heating effect to a succession of different values.

The heating effect of the electric current is proportional to the square of its value at each instant and depends on the resistance of the circuit through which it is flowing. This may be expressed by saying that the rate at which heat is produced in a circuit of resistance R by a current I is equal to the product of R and of I^2; that is, to RI^2. Now if a steady current of 10 amp. is flowing through a circuit of 2 ohms resistance, the rate at which heat is developed is simply $2 \times 10^2 = 200$ watts.

Suppose, however, that the current has one value for a few minutes, another value for a succeeding period, and so on. The problem is to find the single value of current equivalent to these changing conditions so that this single value may be compared with the name-plate rating of the motor to see if the motor is overloaded on the average or not. To make the point more definite let us assume that the circuit under consideration has a resistance of 2 ohms and that the current flowing through this circuit has a value of 10 amp. for 2 min., 5 amp. for 4 min. and zero amp. for 4 min., after which it passes through the original series of values successively for an indefinite time.

The heating effect for the first period of 2 min. is proportional to 10^2 or to 100; of the second period, to 5^2 or 25, and of the third period, to zero. Weighting each of these in terms of the length of the period over which it is effective, we have the following figures: $100 \times 2 = 200$; $25 \times 4 = 100$; $0 \times 4 = 0$; total, 300. Now, dividing 300 by the total time of the cycle, that is, 10 min., we obtain directly the average square of the current for the 10 min. and this is equal to 300/10 or 30. The square root of this average is equal to $\sqrt{30}$ or closely to 5.5 amp. Put into simple language it may be stated that the heating effect through the circuit of 2 ohms is essentially the same if a steady current of 5.5 amp. flows for 10 min. as if 10 amp. flows for 2 min., 5 amp. for 4 min. and no current flows for 4 min.

This simple principle forms the basis for overcoming the difficulty in selecting motor sizes for machine tools in which the demands for power vary widely throughout the duty cycle, and with a clear understanding of the numerical example given above and the principle it illustrates the reader should find no difficulty in understanding the notes to follow in relation to practical shop methods for the experimental determination of the so-called root-mean-square current and its use when judging of the proper size of motor to use for any given machine tool.

It may be stated in advance of the notes on practical shop motor tests that it is always possible, when the necessary test equipment is available to test out a motor as a check on its name-plate rating. For example, in Fig. 1, a laboratory method of testing small motors is shown. Each of the two motors in the foreground is equipped with a brake and a balance for loading the motor up to any desired value. The motor may be operated at what is supposed to be its full normal capacity and observations of the temperatures of the different parts of the machine made until such time as the motor ceases to show any further rise in temperature. A comparison of these values with the standards assigned in the aforementioned rules is then an indication of whether or not the given load has exceeded the safe limits prescribed in the operation of such machinery.

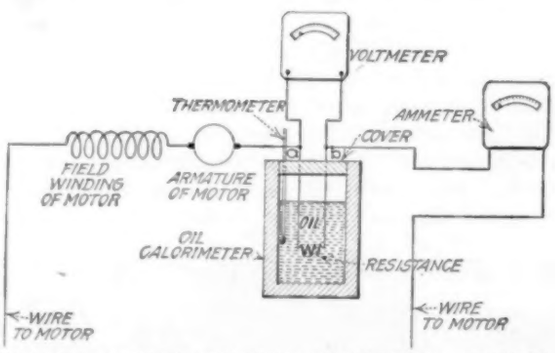


FIG. 3. DIAGRAM SHOWING ELECTRICAL CONNECTIONS FOR THE USE OF AN OIL CALORIMETER IN MOTOR-TEST WORK

However, as it is believed that the average shop will more often be concerned with a determination of the size of a motor to use for a given machine tool than with capacity tests on a motor itself as a check on its own rating, attention will chiefly be directed in what follows to practical tests und shop conditions.

Using the Motor to Measure Power

As an illustration of the use of the motor as a means for measuring the power required to drive a machine tool let us suppose there are half a dozen machines of the same size and kind in a shop to each of which a motor is to be attached for driving purposes. The problem is to determine the size of the motor to employ. In such a case any convenient motor of approximately the right size may be connected up to one of the machine tools and electrical measurements may be made of the power put into the motor during the operation of the given machine tool so as to find the root of the mean square current as explained above.

Several methods for finding the root of the mean-square current are available. One of these is shown in diagram form in Fig. 2, this diagram being drawn up to apply to a series direct-current motor, the field winding and the armature being indicated. A similar arrangement might be employed with a direct-current shunt motor by connecting a known resistance in series with the motor and making the connections of Fig. 2 with respect to the known resistance instead of the series field.

An ordinary watt-hour meter is shown connected so that its current coil is in series with the motor and its potential or voltage coil is placed across the terminals of the series field winding. The motor is now allowed to operate the machine tool to which it is connected over a sufficient length of time so as to get the

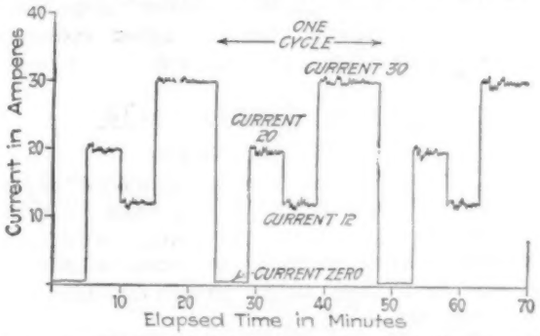


FIG. 6. GRAPHIC CURRENT RECORD (ASSUMED) USED AS THE BASIS FOR FINDING THE ROOT-MEAN-SQUARE CURRENT

full benefit of the ranges of load met with in the ordinary operations of the machine. A reading of the watt-hour meter is taken before and at the end of the run and the time of the run is recorded in hours or fraction of an hour. The difference between the two watt-hour meter readings indicates the energy consumed by the motor field winding during the run and is equal to the product of the resistance R of the field winding, the average square of the various current values I^2 passing through the motor and the time T of the run expressed in hours; that is, watt-hours equal RI^2T.

The resistance R of the field winding may readily be found by connecting an ammeter in series with the motor and taking a simultaneous reading of the current and of the voltage drop across the winding by a voltmeter. R then equals V/I where V is the volts drop across the winding and I is the simultaneous reading of the current. As the resistance of the field winding is likely to change during the run, due to changes in its temperature, a number of readings of V and of I should be taken throughout the run and the resulting values of R averaged. If we let W represent the total watt hours as recorded on the watt-hour meter, then $W = RI^2T$ and hence $I^2 = W/RT$ from which I may be determined by taking the square root of I^2. This value of current I is the single value of current equivalent in its heating effect to all the changing values which were due to the varying load conditions in the operation of the machine tool, and its use in determining the rated input or output of the motor to employ is explained below.

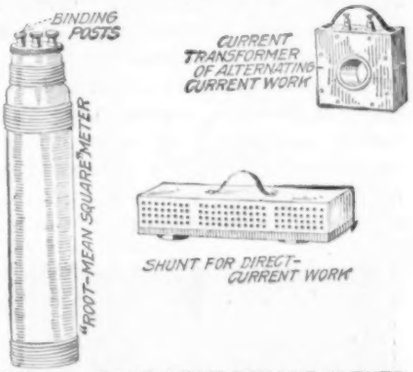


FIG. 4. ROOT-MEAN-SQUARE METER FOR CURRENT MEASUREMENTS, SHOWING SHUNT AND CURRENT TRANSFORMER TO THE RIGHT

Another simple way of measuring the root-mean-square current is outlined in Fig. 3, which shows an ordinary oil calorimeter connected in the motor circuit. A resistance is immersed in a pail of oil, and the value of this resistance R is determined by taking simultaneous readings of the ammeter and voltmeter connected at a and b, the value of R will represent the total resistance between a and b, including that of the wires leading to the resistance in the oil from a and b. Several readings of V and I should be taken as the run progresses to secure an average value of R.

Principle of the Device

The principle of this device is based on the fact that the amount of heat given off by the resistance due to the electric-current flow expressed in electrical units is equal to the amount of heat received by the oil expressed in heat units, neglecting radiation for which due account may be taken by calibrating the device in advance by means of a steady current.

The heat given off by the resistance R in a run of t seconds is equal to RI^2t joules or $\frac{1}{4.2}RI^2t$ gram calories. The heat absorbed by the oil (neglecting radiation) is equal to the weight of oil in grams W, times the specific heat of the oil s, times the rise in temperature T, in deg. C., as observed by the thermometer from reading before and at the end of the run. Equating these two quantities we have:

$$RI^2t = 4.2\,WsT \qquad \text{from which } I^2$$

may be found, since everything except I is readily determinable, i.e.,

$$I^2 = \frac{4.2\,WsT}{Rt}$$ and I, the root-mean-square current, is equal to the square root of I^2.

A simple device based on the principle of Fig. 3 con-

sists of a vacuum bottle containing water, as in Fig. 4, where the resistance is placed in the vacuum bottle[2] To the right a shunt is shown for use with the root-mean-square meter and also a current transformer for reducing when desirable the current actually passed through the meter when measuring direct currents and alternating currents respectively. Its use is quite similar to that of the oil calorimeter.

A very convenient method, and in some respects a more satisfactory scheme than either of the two preceding methods is by using the graphic ammeter or wattmeter. In Fig. 5, for example, there is shown an ordinary graphic meter adjacent to a lathe ready for use in making an analysis of the lathe operation. Suppose the graphic record in such a case takes some such form as shown in Fig. 6. Here the successive values of current during one of the duty cycles of the machine tool operated by the motor have fairly well-defined values for their respective time intervals. Thus in the duty cycle marked in the diagram the current is practically zero for 5 min., 20 amp. for 5 min., 12 amp. for 5 min. and 30 amp. for 9 min., this cycle being repeated indefinitely.

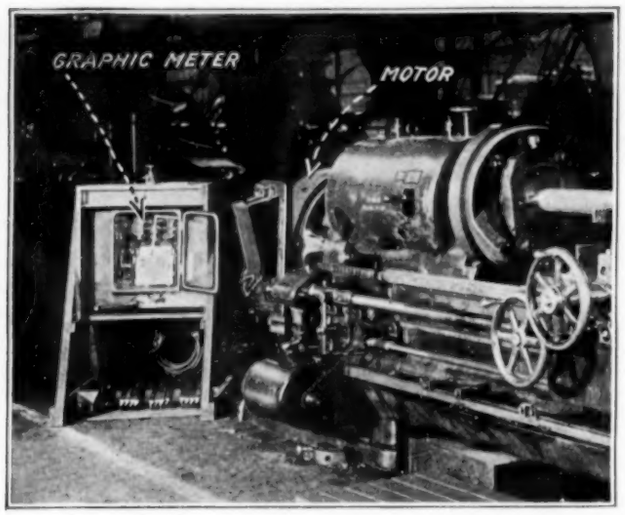


FIG. 5. GRAPHIC METER IN POSITION FOR ANALYSIS OF LATHE OPERATION

The root-mean-square current as indicated from this chart is found as follows: 0×5 min. $= 0$; $20^2 \times 5$ min. $= 2000$; $12^2 \times 5$ min. $= 720$; $30^2 \times 9$ min. $= 8100$; (total time $= 24$ min.) 10,820.

The average square of the current is then 10,820/24 $= 421$ and the root-mean-square current is found by taking the square root of 421 or $I = 21$ amp.

Using these figures to determine the horsepower of the motor necessary for the work corresponding to the chart we find that if the pressure of the supply circuit is 220 volts and the efficiency of motors of this class is on the order of 85 per cent., the horsepower required is:

$$\frac{220 \times 21}{746 \times 0.85} = 7 \text{ as the nearest whole number.}$$

This value of horsepower may be termed the root-mean-square horsepower, inasmuch as it has been based on the root-mean-square current. The actual horsepower rating to select depends partly on the standard ratings available and partly on the periods of rest during which the motor has a chance to cool and on the amount by which the higher current values exceed the root-mean-square value.

In the particular case just cited a current of 30 amp. lasts for 9 min. out of the 24, or roughly for one-third of the time, and 30 amp. is about 50 per cent. above the root-mean-square current value. If the actual horsepower rating selected for such a case is lower than the root-mean-square value, or even the same, and the overload capacity is depended upon for the high currents, informtion should be secured from the motor manufacturers as to whether the overloads indicated by the graphic records can safely be expected from a motor of the rating chosen.

In addition to the horsepower determination due regard should be taken to obtain a motor with suitable operating characteristics in such matters as range of speed adjustment and starting torque to accommodate the load to be driven.

Graphic Meter More Satisfactory

From what has been said above it will be apparent that the graphic meter is more satisfactory than the other measurements of root-mean-square current described in that such a graphic record furnishes not only the data for giving this current, but it shows overload conditions and the duration of such overloads as well as of rest periods.

These methods for determining horsepower are applicable either to machines where motor drive is contemplated or for a study of machines which are already motor driven. In the latter case they furnish a convenient means for ascertaining whether or not the motor is operating at its full rated capacity or the extent of the under or overloading as the case may be. It is obviously to the interests of the shop to make use of some such scheme in changing motors from one machine to another rather than to depend entirely on guesswork or even merely on judgment.

Incorrect Lead of a Die

By O. F. Kuhlman

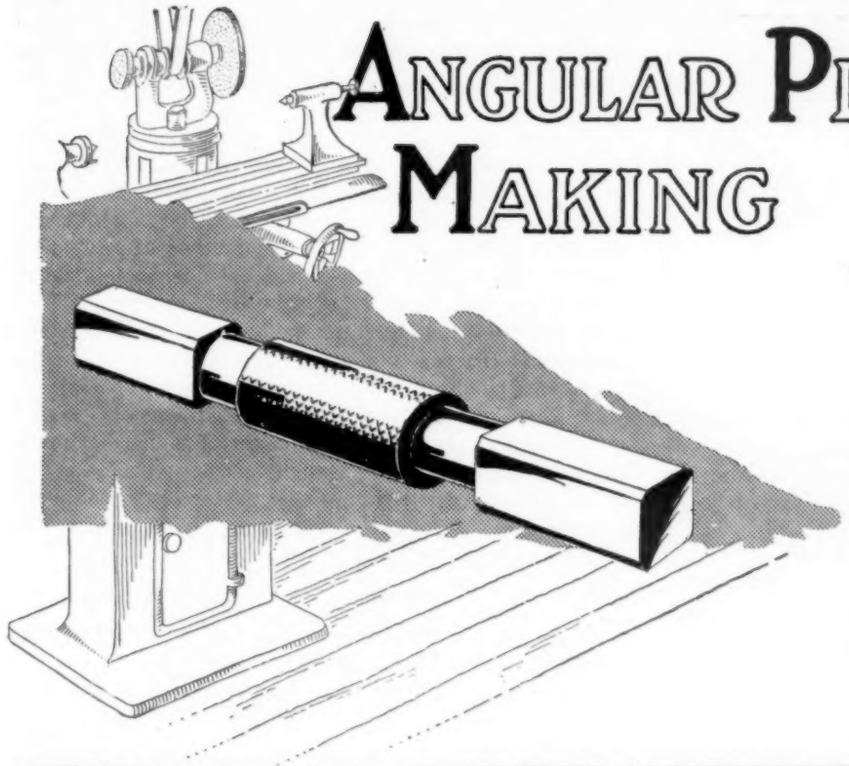
Recently there came to our shop the job of threading some ¾-in. rods, for about 15 in. of their length and fitting to each a cylindrical nut about 5 in. long. The nuts were of such shape as to permit chucking and they were first chased nearly to size and then finished with a new tap.

There were 40 of the pieces to be fitted, and as this would constitute a somewhat tedious job if the threads were cut in the lathe an attempt was made to cut them with a die.

The first piece had been cut nearly to size in the lathe and then finished by running the die over it. This fitted the nut all right so the man cut the next eight or ten, using the die alone before trying any more in the nut. When he did try one he found to his surprise that it would go only about halfway through the nut.

Readjusting the die to cut smaller he ran it over the piece again with no better results. Successive adjustments and recuts until the threaded piece was perceptibly loose on entering the nut failed to get it through, and finally one of the nuts was sawed open lengthwise when it was found that the male thread was one whole turn short in the five inches.

[2] A description of this instrument is given in detail in the "Electrical Journal," Vol. XIV, No. 2, 1917, page 59.



ANGULAR PLUG-GAGE MAKING

By Hugo Pusep

The gagemaker's skill and ingenuity are nowhere demonstrated to better advantage than in planning and performing the operations necessary for grinding and lapping angular plug gages to conform to the specified limits of accuracy. In this branch of gage making it is equally true that the errors in preliminary operations, if not taken into account at the proper time, will accumulate and cause serious defects in the gages, which will be difficult if not impossible to eliminate in later operations.

A COMMON type of gage used to gage rectangular holes is reproduced in Fig. 1. The distances *A* across the flats and over the rounded corners *B* vary in go and no-go end to the degree of accuracy necessary in the gaged product. To anyone familiar with the use of these gages it is apparent that they will not function properly unless all the flats are perfectly square and equidistant from the center and the four rounded corners concentric. When machining the gages the measuring ends are left cylindrical to facilitate the finishing of the rounded corners, and after hardening, these ends are ground and lapped to size, similar to any ordinary cylindrical plug gage. It is not out of place to say that the grinding of both ends must be done on perfectly true centers; the reason for this will appear later.

Preparing the Master Block

In order to have perfect control of measuring and checking the gage while grinding and lapping the flats the master-block method is the most accurate and simple one for this class of work. A square block of cast iron is bored about $\frac{1}{32}$ in. larger than the knurled part of the gage, Fig. 2, and is drilled and tapped for eight setscrews, two on each side, as at *A*, Fig. 2. This master block, as it is commonly called, should be made as small as practicable and still accommodate the setscrews, and the gage should protrude far enough from both ends to allow the grinding wheel sufficient working room.

With both ends ground and lapped to a true cylinder and to the finish dimensions the gage is placed in the cast-iron block, Fig. 2, and is adjusted by the eight setscrews till there is no variation on the indicator when being tested on the surface plate as shown by the diagram, Fig. 3. While testing this setup the block *A* is laid on its four sides in rotation, and the indicator *B*, held in the surface gage *C*, is passed over the finished cylindrical end of the gage. If the block has been carefully ground by the aid of a good angle plate it is possible to set the gage central to the block by adjusting the eight setscrews. As a general rule, however, where great accuracy is required the master block must be scraped to finish on all four sides. This is done with the gage in position and setscrews tightened, and is continued till a most sensitive indicator shows no variation on the gage in any of the four positions. A knife-edge square is used at all times while scraping, and when no light appears between the block and the square

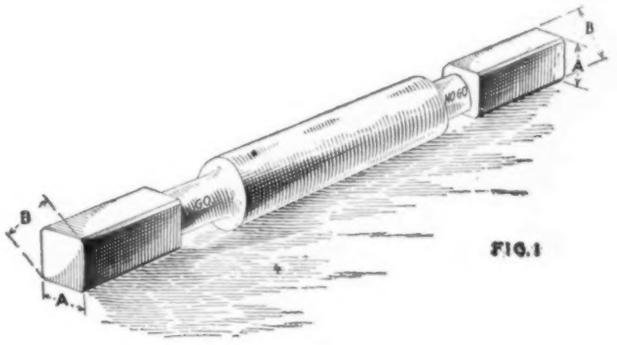


FIG. 1

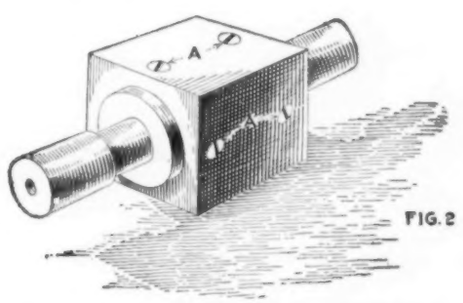


FIG. 2

FIGS. 1 AND 2. GAGE AND MASTER BLOCK

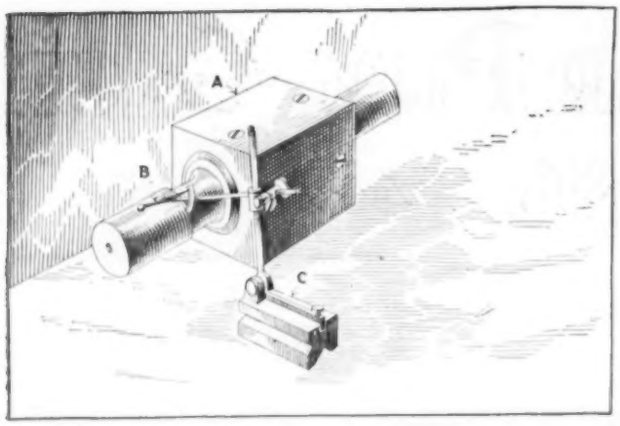


FIG. 3. METHOD OF USING INDICATOR

blade in four positions of the former the gage is ready to have the flats ground on it.

In order to do good work a surface plate, which is known to be a true plane, is a most important adjunct, as is also a knife-edge square that is absolutely accurate and a very sensitive indicator. The master block should be stamped from 1 to 4 in rotation, on its four sides, which will save confusion in grinding and lapping. When ready to begin scraping the block a side which is nearest the center of the gage is found, which is then scraped to a plane. Now when the indicator is set to read zero over the go end of the gage it should read over the no-go end exactly one-half more than the difference in their sizes. For instance, if the no-go end measures 0.001 in. larger the indicator reading should be 0.0005 in. over zero on that end. Let us assume that the side of block just finished is stamped 1. Now a block is laid on the side marked 3. A second surface gage with an indicator is now necessary to finish-scrape that side, because the block must be tested at its four corners for parallelism as well as the gage itself. Indicating is a quicker and surer method than using micrometer for this purpose. A gagemaker must use judgment in finishing the second side. If there are two or three thousandths of an inch of metal to remove, the bulk of it should be taken off on the surface grinding machine, then the scraper used for the final tenth or so. The third side, which is marked either 2 or 4, is now scraped. Only one indicator is now required, but the knife-edge square is constantly employed in testing the two finished sides for squareness as the scraping proceeds. The remaining side of the block is scraped similar to the one marked 3, two indicators being used in conjunction with the square to detect any accumulated errors.

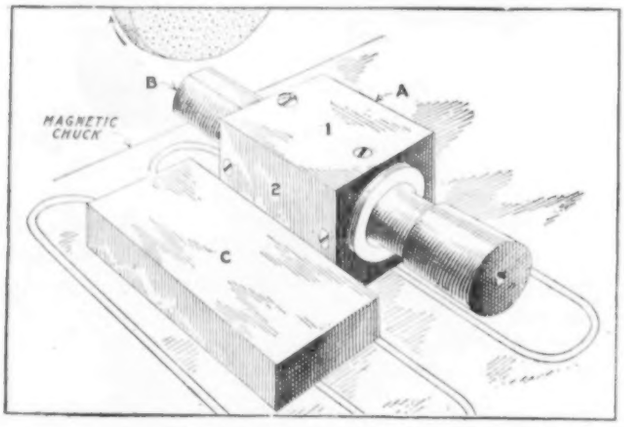


FIG. 4. ROUGH-SIZING ON GRINDING MACHINE

The reason for grinding both cylindrical ends of the gage on true centers, as previously stated, will be clear to anyone after the description of preparing the master block. If the ends of the gage had been ground on centers which did not run true the method of setting the gage in the master block would be much complicated; in fact the block would have to be scraped separately for each end of the gage, thus doubling the time for this operation. In case the design of the gage should be such that the knurled central part is smaller in diameter than the distance over the rounded corners a split sleeve is made, the outside diameter of which is slightly greater than that of the rounded corners, thus allowing it to be inserted easily into the master block, the diameter of the hole in the sleeve being $\frac{1}{32}$ in. larger than the knurled handle of the gage.

GRINDING THE GAGES

The gage is now ready to have the four flats ground, which is accomplished on a magnetic chuck in the surface grinding machine. The face of the magnetic chuck must be tested for parallelism with the grinding wheel, and if found to be out of true, a facing cut should be taken over it. It is not a very simple matter to true a magnetic chuck properly, and the tendency of the magnetic poles to charge the grinding wheel must be taken into consideration. A good way of accomplishing this is to use a medium wheel for the operation, employing a very coarse feed and a slight cut; grade M, Norton or Carborundum Co. gives satisfaction. Under no circumstances should a hard wheel be used, because it glazes and consequently burns the face of the chuck, resulting in a rough surface. Soft wheels are also undesirable because of their quick-wearing qualities.

The flats on both ends of the gage should be roughed out to within 0.005-in. or so of size. This is accomplished as illustrated in Fig. 4. The master block *A* with gage *B* is laid on the magnetic chuck with the side numbered 1 uppermost. A parallel *C* is placed against the block, as shown, to prevent shifting under pressure of the cut. A soft wheel should be used for this operation; a Norton grade *H* or its equivalent will do the work. The reason for always using a soft wheel for roughing is that it cuts fast and does not burn the gage; a cut 0.0005 in. or even deeper can easily be taken. Once the wheel is set for the first side its position should not be altered till all eight flats have been ground with the same setting, because it prevents mistakes, and the fact that the four flats on the master block are numbered will remind the gagemaker when the cycle of operations on either end of the gage has been completed. If the above described procedure is followed there is little chance of grinding off too much by mistake, as every time a cycle of operations is completed, it will suggest the measurement as a matter of course.

Success at this stage depends on a few time-worn kinks, but which cannot be too strongly emphasized. The grinding wheel should be re-dressed immediately it shows signs of beginning to charge. Whenever changing the position of block *A*, Fig. 4, in relation to its sides, the parallel *C* is also removed and the surface of

the magnetic chuck wiped clean with a piece of waste; but before replacing the block the palm of the hand should be passed over the chuck and the contacting side of the master block in order to remove the last traces of dirt, it being a well-known fact that the human hand acts similarly to the finest chamois leather.

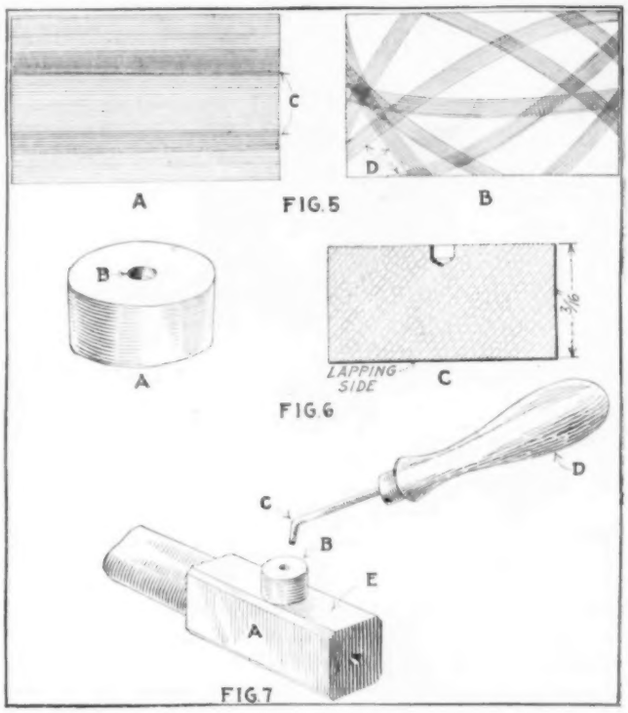
The last few thousandths is taken off with an elastic wheel of about grain 60 in order to obtain as fine a finish as possible, thereby leaving only a small fraction of a thousandth for the lapping operation. With a smooth-grinding finish there need not be more than 0.0001-in. left on for lapping, and to obtain this, free from chatter marks, all play in the grinding-machine spindle must be taken up and the finishing wheel nicely balanced. While finish-grinding only hand feed should be used. This is because the adjustable dogs on the grinding-machine table on engaging the reversing lever set up a vibration that will show on the ground surface as chatter marks. Taking the last few tenths off by hand feed will eliminate this to a large extent, resulting in a very smooth finish.

Lapping

This operation should be looked on as a smoothing or polishing of the gage flats, and when an extra-good grinding job has been performed the removing of grinding-wheel marks should bring the gages to size. However, as a precautionary measure, slightly more metal is left on for lapping than is absolutely necessary to eliminate the wheel marks. The old saw, "It is easier to take off than to put on," holds good here as elsewhere.

Preparatory to lapping, the gage, which is still held in the master block, is placed on the surface plate and tested with an indicator in the surface gage. Taking the end that it is intended to lap first, the indicator is passed over all the flats in rotation, noting the difference in reading, if there are any, and commencing the lapping on the highest side. Copper has proved to be the best material for laps in this class of gage work. For larger sized gages the best form of lap is a small rectangular block of copper, the lapping side of which has been worked to a true-plane surface. This result is acquired either by milling, shaping or grinding, but before beginning to use it the copper block is rubbed over a good true cast-iron lapping plate. This puts it into condition of a true plane.

For first-class results the copper lap should not be as large as the surface which it is to lap. Experience has taught that the lap should not be larger than about half of the length and two-thirds of the width of the flat surface on the gage. A fine grade of Turkish emery is used for the lapping compound, as this cuts quite fast but leaves a good, smooth surface. The copper lap is charged on a hardened and ground steel plate. Loose emery is sprinkled over the charging plate, the surface of which has been previously wetted with benzine or kerosene. This helps to spread the emery evenly over the surface. A circular motion should be imparted to the lap while pressing it to the charging plate, to embed the emery properly. Although the method of charging a surface lap may seem to be a simple operation there is quite a difference in the performance of a lap that has been properly charged. The diagram *A* in Fig. 5 shows in exaggerated form a lap, the surface of which has been charged by moving it only back and forth over



FIGS. 5, 6 AND 7. SMALL LAPS FOR LOCAL LAPPING

the charging plate. At *C* are shown streaks of emery particles embedded in the lap. This condition is hard to prevent in moving the lap in a straight path over the charging plate. The result of this condition of the lap being that the heavier charged portions *C* wear correspondingly minute grooves in the gage surface. As there is only a limited surface on the gage to work on, the lap cannot be so readily turned to counteract these grooves, thus resulting in a more or less faulty surface. The diagram at *B*, Fig. 5 shows the surface of a lap that has been given a somewhat circular motion in

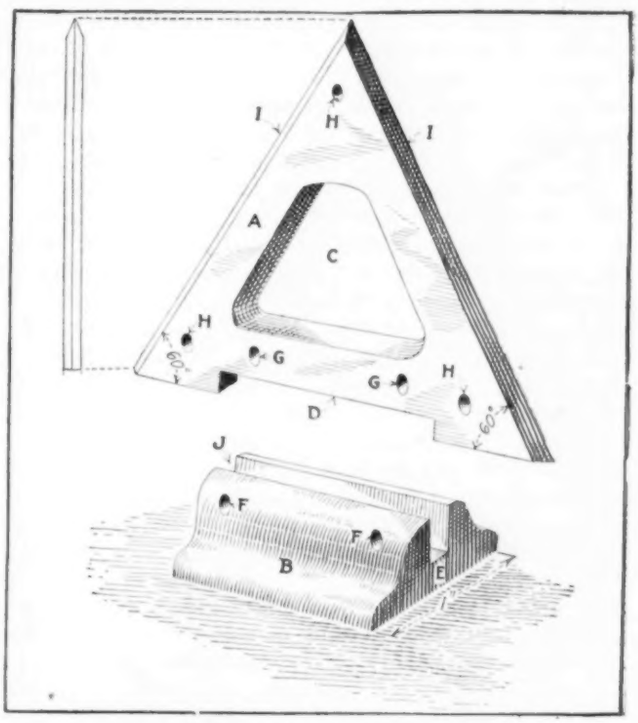


FIG. 8. SIXTY-DEGREE MASTER ANGLE

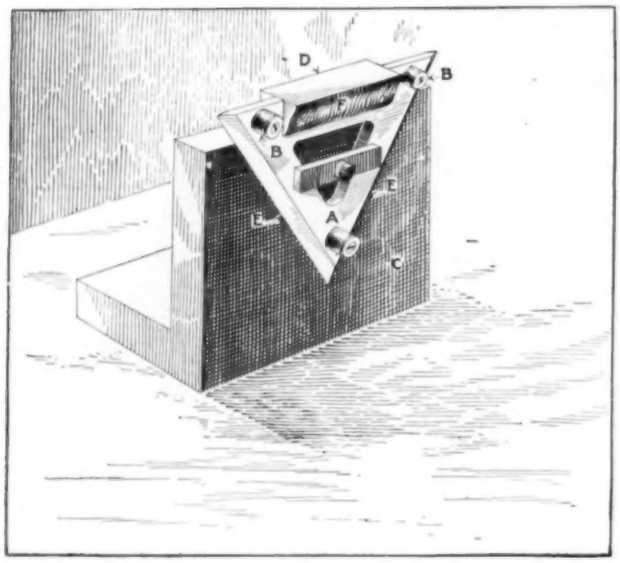


FIG. 9. SET UP OF MASTER ANGLE

charging. Heavily charged portions of the lap are shown by lines *D*. It becomes clear now that no matter whether the lap is moved lengthwise or sidewise over the gage surface it will cut evenly, because all heavily charged positions of the lap will act at all points over the surface lapped and at each pass of the lap.

The Disk Lap

For lapping the flats on very small gages where the rectangular lap just described could not be conveniently held a form of lap shown at *A*, Fig. 6, is used. As can be seen from the sketch it is in a form of a disk.

These disks are parted off in the lathe from a copper rod of suitable diameter and are about $\frac{3}{16}$-in. thick, the diameter being slightly less than the width of the flat surface to be lapped. Only one side of the disk is used for lapping, the opposite having a small, shallow hole *B* drilled at the center for the purpose of working the lap, as will be explained presently. The cross-section *C*, Fig. 6, shows plainly the form of this kind of lap. Grinding or scraping is the easiest way of bringing the lapping side of these disks to a perfectly plane surface, after which they are charged with emery in a manner already described in the case of rectangular laps. Fig. 7 shows the working of the disk lap. *A* is the gage, *E* the surface lapped, *B* the disk lap, while the bent wire *C* in the file handle *D* forms a convenient means of holding and working the lap. The bent end of the wire *C* seats itself in the small drilled hole as already explained in the construction of the lap, and transmits the pressure from the file handle to the lap. This form of lap is very effective and convenient to use, not only in angular plug gage work but in all work where the surface to be lapped is very small or not easy of access.

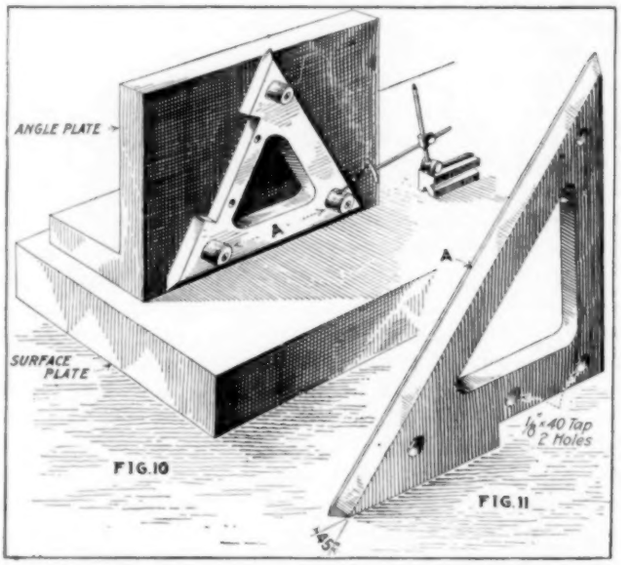
Lapping of gaging flats on angular plug gages is performed with the gage still in the master block in which it was set up and ground. It is not removed from the surface plate while lapping, because frequent measuring with the indicator, square and micrometers is necessary. When getting close to finish size the measuring micrometer is set to Johansson blocks and the spindle locked. In this way a gagemaker can work to extremely close limits by feeling alternately over the gage flats and the Johansson blocks. A slight variation in size over the gage flats can thus easily be detected and corrected by lapping. When a tight place has been found the indicator is passed over the flats concerned and the high spots noted, which are then reduced with the disk lap till the opposite flats show a parallelism within the limits specified.

Hexagon and Octagon Gages

After square plug gages the hexagon and octagon gages are the ones often met with in practice. The grinding and lapping of these are identical to square gages, namely, in scraped master blocks. As the commercial bevel protractor is not considered accurate enough for preparing these blocks special master angles are necessary. In making these master angles the aim should be to produce a theoretically perfect angle, and although this entails quite an expense in the first place it will be found a good investment later on, not only on angular gage work but in a large variety of tool work. The different uses of the master angles will naturally suggest themselves where such angles are available, as reference gages, means of accurately setting up jigs for boring holes at an angle, setting the planer head for dovetail work, etc.

Developing a 60-Deg. Master Angle

The sketch in Fig. 8 shows a completed 60-deg. master angle. For the sake of clearness the blade *A* and the base *B* are shown separately. The blade is made of good quality tool steel about $\frac{1}{8}$ in. thick and machined as shown. The opening *C* is for lightening the blade. The recess *D* corresponds in depth to the thickness of part *E* in the base. The base *B* can be made either of tool steel or machine steel carbonized and hardened. The dowel holes *F* in the base are transferred to the blade, as at *G*. For this reason that part of the blade is protected by sheet asbestos during hardening, so as to leave the locations of the holes soft enough for drilling and reaming. The three equally spaced button screw holes *H* are drilled and tapped with a $\frac{1}{8}$ x 40-thousandths tap, and the knife edges *I* are milled to 60-deg. bevel, after which the blade is ready for hardening. After hardening, both faces of the blade are ground parallel on the



FIGS. 10 AND 11. INDICATING THE BUTTONS AND MASTER ANGLE FOR AN OCTAGON

surface grinding machine. Buttons are affixed in three positions *H* and are located equidistant by the aid of Johansson blocks. No care should be spared here, because the accuracy of the master angle will depend entirely on correct location of the buttons. The base *B*, Fig. 8, is now fitted to the blade and secured by two dowel pins as already explained. The assembled master angle *A*, Fig. 9, is secured to an angle plate *C* in the manner shown, with the buttons *B* leveled accurately to an indicator on the surface plate.

The bottom edge *D* of the master angle and its assembled base is now ground perfectly flat on the surface grinding machine, after which the base *F* is detached from the blade and the measuring edges *E* are set up and ground in the same manner as the bottom edge. The grinding of the 60-deg. beveled edges is accomplished either by the aid of an adjustable angle plate or in a tilting vise. About 0.003-in. has proved to be the correct flat to leave on the knife edges. After completing the grinding of the blade it is lapped on its two knife edges, while the progress of the lapping is closely watched as illustrated in diagram Fig. 10 by indicating on the surface plate over the two buttons *A* nearest the edge being lapped. A ground and lapped test plate of convenient length and size, which is true to a straight edge, is used for testing the knife edge on the master angle blade for straightness. The master-angle blade and its base are now reassembled, and lapping the bottom edge of blade and the base completes the job.

Developing Master Angle for Octagon Plug Gages

In developing the master angle for octagon gages a somewhat similar yet distinctive method is employed. Fig. 11 shows the blade, which from the similarity to the 60-deg. angle blade needs no further explanation. It might be said, however, that the knife edge *A* is ground and finish-lapped before the base is attached, which in all respects resembles the hexagon angle base. Before assembling the base with the blade two buttons are affixed by the tapped holes shown. These buttons need

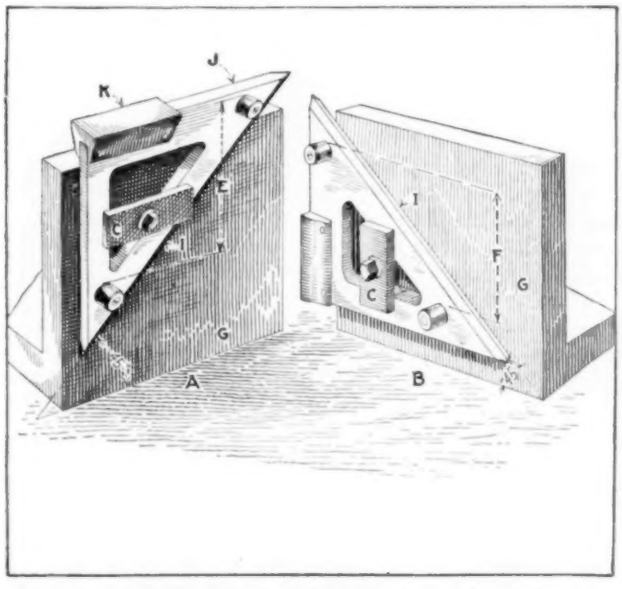
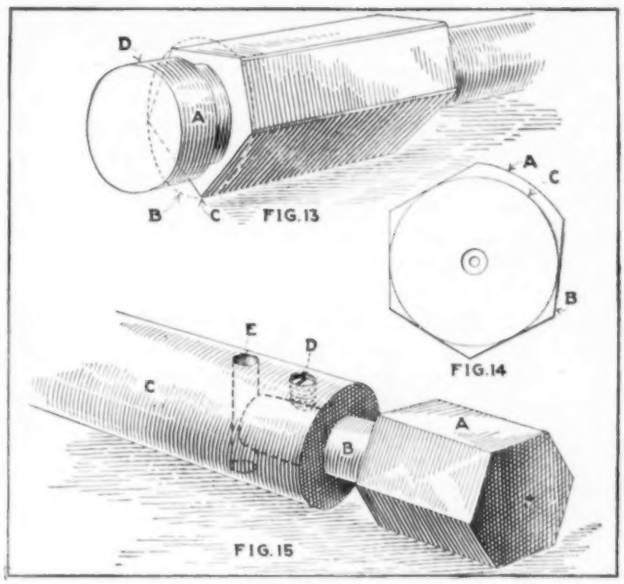


FIG. 12. METHOD OF SETTING MASTER ANGLE FOR GRINDING



FIGS. 13, 14 AND 15. OTHER ANGULAR PLUG GAGES

not be any certain distance apart, but they must both measure the same distance from the knife edge *A*.

For grinding the bottom edge and the assembled base of the 45-deg. master angle a practically square angle plate is necessary. The two views in Fig. 12 show diagrammatically the method of setting the master angle preparatory to grinding the base, reference letters in both views being the same. As shown the master angle is held by the clamp plate *C* and capscrew *D* to the face of the angle plate *G*. The distance *E* in view *A* is now measured with indicator and Johansson blocks, then the angle plate is turned over to rest on its sides as at *B* and the distance *F* is measured similarly to distance *E*. When, after due adjustment, no difference in the two measurements is found, the knife edge *I* is at an angle of 45 deg. to the surface plate. Now the bottom edge *J* of the master angle and the base *K* is ground and a few passes over a lapping plate will complete the master angle.

Master measuring angles of other than 60 or 45 deg. can be developed successfully by the bottom method, as already described in the two previous examples. The sine bar is also used to advantage in this class of work.

Odd-Sized Angular Plug Gages

Angular plug gages having an odd number of sides, although not frequent, do occur in practice. Of these the triangular and pentagonal gages are the ones most commonly used. These gages, as in the case of ones previously described, are ground and lapped in master blocks, the finishing of which to correct angles is accomplished by special master angles, the construction of which needs no further explanation in view of the data already given. There are, however, some special features about measurement of odd-sided gages that must be dwelt upon. Fig. 13 shows a pentagonal plug gage. The cylindrical end *A* is ground to diameter that is tangent to the flats on the gage in its finished condition. This cylindrical end *A* and the diameter *B*, which will afterward form the rounded corners *C*, are ground and lapped first. Then the five flats are ground, setting the measuring indicator to the highest point *D* on the

cylindrical end. Thus with an indicator reading to ten thousandths of an inch it is easy to determine the progress of grinding and lapping the flats. This method of accurately measuring the distance of flats from the center by indicating over an extra cylindrical end applies to all other odd sided gages. Should there be occasion to make a gage that has one or more flats of varying distance from the center then those furthest from the center are finished first and the cylindrical end reduced in diameter till it comes tangent to the next flat closer to the center of the gage.

There is another type of angular plug gage having a large circular part besides the flats. An end view of such a gage appears in Fig. 14. The circular part *A* should be looked on as merely an enlargement of the cylindrical or rounded corner, and if treated as such it should cause little worry to the gagemaker as to the method of finishing the gage. The flats *B*, if odd in number, are finished to the cylindrical measuring end left for that purpose on the gage and represented in this instance by line *C*. This cylindrical measuring end in odd-sided gages is ground off after the gage has been completed and passed by the inspector.

Designing Gages for Rapid Production

It might be fitting in this article on angular plug gages to suggest improvements in design of these gages that would result in a great saving of time where quantity production is desired. American machine shops are sure to be called upon in the near future to contribute the larger part of their capacity to reconstruction work. This means that quantities of gages will be needed to produce machine products of every kind on the basis of interchangeability.

In Fig. 15 is shown a type of an angular plug gage which has detachable gaging ends. These gaging ends *A* have short taper shanks *B* fitting into a reamed hole at each end of the knurled handle *C*. The setscrew *D* bears against a flat on the taper shank, thus furnishing added security against the possibility of pulling the gaging ends off the handle should the gage be jammed tightly into the hole being gaged. The hole *E* provides means for driving the gage off the handle when required. Any standard taper is suitable for the shanks.

The advantages of this detachable design for angular plug gages are numerous, the more prominent being the reduction in cost of producing the gages in the first place and much lower upkeep expense, as in the case of making renewals, etc. Where solid double-ended gages are used, as described at the beginning of this article, the master blocks in which they are ground and lapped must be adjusted for each individual gage and sometimes ground or scraped all over in order to be within the limits of accuracy necessary. The taper shank of the detachable gage is ground concentric with the body of the gage, so when a master block is once finished for the first gage it will need no adjustment or rescraping, the tapered hole at each end of the master block centering each subsequent gage properly. A drift hole of course must be provided for each hole in the master block to remove the finished gaging ends.

Angular plug gages are made of tool steel, machine steel carbonized not being practicable on account of the stock that has to be removed by grinding the flats after hardening. In the solid type of gages therefore the large amount of expensive tool steel in the knurled handle is wasted. The handle *C* in Fig. 15, being of machine steel, eliminates this waste of expensive material. Further the same handles can be used for different gages or when changing the design of the gaged hole and also in renewing worn gaging ends. If, for instance, the product of any shop calls for three sizes of square hole gages, the sizes being 1 in., 1¼ in. and 2 in. across the flats respectively, the shanks of all these sizes could be of the same taper. Then only one master block, just large enough for the 2-in. gage, could be used for grinding and lapping all the square hole gages in the shop.

This last item alone should convince any gage user as to the practicability of the detachable design. Even on small quantities this design is a wonderful time saver. With the return of the country to peace basis and the resumption of keen competition among the machinery producing establishments not only of America, but of the entire world, advantage should be taken of all improvements whether in the processes of manufacture or improvement of design.

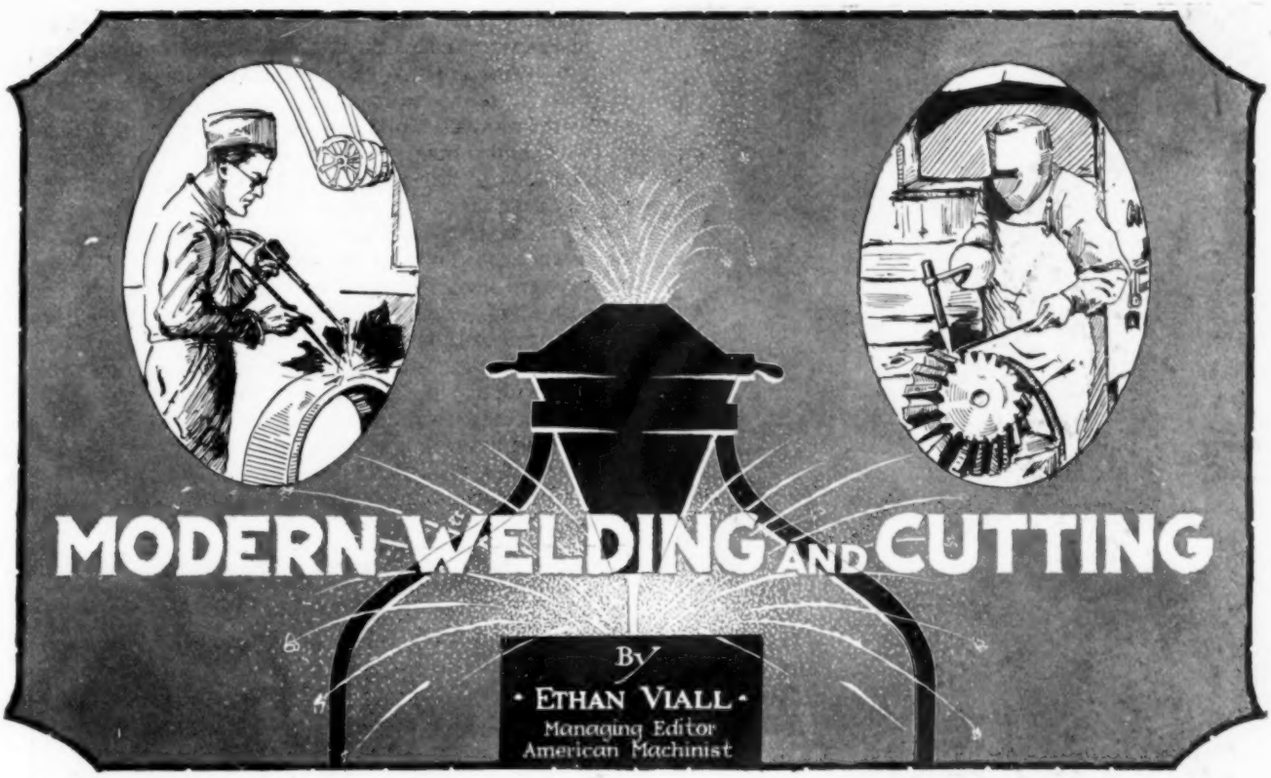
A Successful Apprentice Toolmakers' School

By C. R. Dooley
Committee on Education and Special Training, War Plans Division, General Staff

I read with much interest the article entitled, "A Successful Apprentice Toolmakers' School," in the *American Machinist* of Feb. 20. The experience cited coincides exactly with that of the Committee on Education and Special Training with its vocational schools. During the past summer and fall we operated 167 schools, training 140,000 soldiers in 67 different trades.

I would take exception to the last statement of the article which reads as follows: "The secret probably lies in their rule of admitting only high-grade machinists of long experience to the course, and those only who have served long with the company and themselves ask for the opportunity." Undoubtedly this had a great deal to do with their success, but our experience this summer proved almost equally successful with men who had had practically no experience in the trade they were learning. Garment makers were trained as very good blacksmiths, bank clerks as pattern makers, salesmen as tinsmiths, etc. The length of our training was the same as the one cited in this article, namely; two months.

As a result of the war there is surely evidence in favor of the training of men following their lines of native ability rather than their trades and experiences. Thousands of men are today employed in work not at all suited to them and which they do not like. A great upheaval like a war throws them into their proper environment and they surprise us with the character of their work. Nowhere is this more apparent than in the training of the thousands of officers required by the army. As you know the training was largely done in a period of three months in the face of the fact that the regular army officers, and all of us for that matter, said that two years would be necessary at least. Given the proper method of instruction and the line of work suited to the individual, according to his native ability and temperament, the speed with which excellent results can be accomplished is simply marvelous.



VII. Thermit Welding of Cast Iron and Other Parts

The welding work described in the first part of this article is closely allied to the repair of machine tools in general, while the latter part describes some special small-tool applications.

THE Thermit process, while adapted to the welding of cast iron, cannot be used on all cast-iron welds owing to the difficulty in many cases of allowing properly for the shrinkage of the metal in the weld when cooling. The Thermit steel contracts twice as much as the cast iron, so that in certain constructions shrinkage strains will be set up in the weld causing cracks. This difference in shrinkage often makes it impractical to weld long cracks in thin sections. As a general rule we should say that if the length of crack is more than eight times the thickness of the material a Thermit weld should not be attempted, because on account of the difference in shrinkage along the line of the fracture small hair-line cracks will appear perpendicular to the line of the fracture. These cracks however being perpendicular to the line of the weld are often therefore of little consequence and do not interfere with the strength of the weld.

It is also not usually feasible to weld cracks in cast-iron cylinders, pots, kettles and similar castings. Where there is a clean break between two sections or where the section to be welded can be completely cut through and can be separated a sufficient amount to allow for the contraction in the weld, and also where the length of the weld is not more than eight times the thickness of the material, a Thermit weld would be entirely practical and can be made in exactly the same way as outlined for the welding of wrought-iron and steel sections.

In cases where the crack can be opened up mechanically or by heating a parallel part to a dull red a weld may be made, but it must be remembered that expansion gained in this way must be a little more than the expansion of the parts next to the weld during the preheating.

Care should be taken in preheating for cast-iron welds not to heat the sections too hot; a dull red is sufficient. One should be careful to keep the heat going until the mold is thoroughly dried out.

The mixture of Thermit for the weld should be different than for wrought iron and steel, and for this purpose the special mixture known as cast-iron Thermit is recommended. This consists of plain Thermit with which is mixed 3 per cent. ferrosilicon 50/50 and 20 per cent mild-steel punchings, i.e., to every 100 lb. of plain Thermit is added 3 lb. of ferrosilicon and 20 lb. of punchings. This gives the best results on cast iron and produces a homogeneous metal in the weld.

Welds on cast iron are a little more difficult to machine than welds on wrought iron and steel, as the metal along the line of junction of the Thermit metal and the cast iron is apt to be a trifle hard due to the absorption of carbon from the cast iron. This objection is not a serious one, however, and hundreds of welds have been completed with the most satisfactory results.

Examples of Cast-Iron Welds

In order to show the possibilities of welding various cast-iron pieces with Thermit a few examples taken from actual practice are given.

Fig. 75 shows how a new jaw was burned onto the frame of a heavy shear, in the shops of the Raleigh Iron Works Co., Raleigh, N. C. The job was done in 1906 and the machine is still in service. This machine was designed for shearing 1½ x 6-in. bars, producing an enormous strain on the jaws. A large part of the corner of the lower jaw, weighing about 75 lb., broke

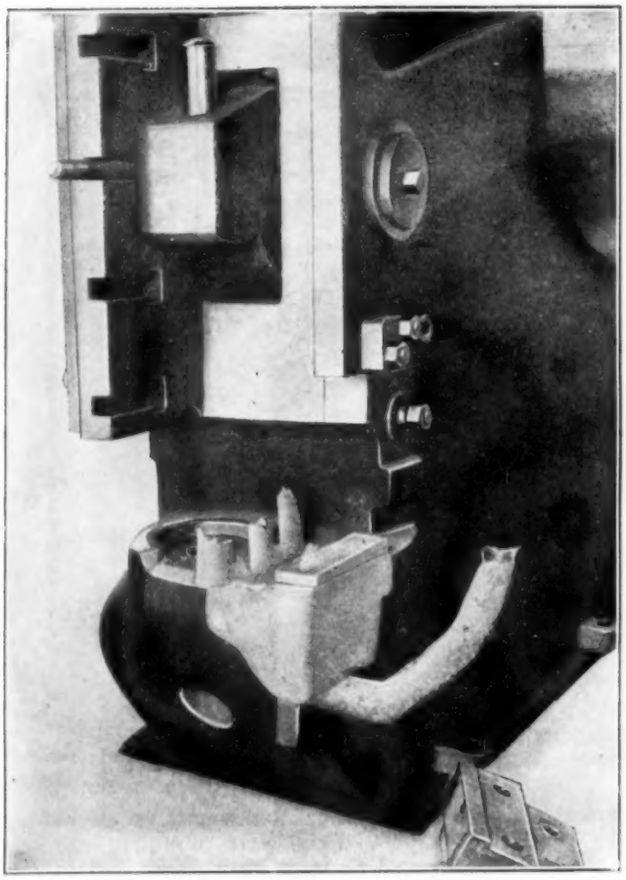


FIG. 75. NEW JAW BURNED TO FRAME CASTING OF HEAVY SHEAR

off. It then became a question of getting a new frame or burning on a new jaw corner, which would require the fusing of a surface about 1 sq.ft. in area in order to obtain a thorough union. It was finally decided to try Thermit. The surface of the break was chiseled off for the reason that a cast-iron break is usually glazed with graphitic carbon. The mold was then put in place and well luted with fire clay where there was any danger of leakage. Moist sand was also rammed around the mold and other parts as a further precaution. The surface of the fracture and the stock around the jaw was then heated through the gates and risers by means of gas jets, in order that the casting might be thoroughly heated and all moisture driven out. The gas torches were kept in action several hours. A crucible containing 175 lb. of Thermit was then put in position for tapping into the mold. After the reaction the Thermit steel was run into the mold and at once fused the entire surface of the fracture. In the meantime a ladle of molten cast iron containing about 600 lb. of metal was held in readiness and was superheated by means of a Thermit semisteel can. As soon as possible after pouring the Thermit, this cast iron was poured into the second gate, shown at the front of the jaw, and this forced the Thermit steel out of the mold after it had served its purpose in bringing the surface of the jaw to a welding or fusing heat. The result was a new corner of cast iron burned onto the old jaw. The illustration shows the two gates and four risers before they were trimmed off. In *Reactions* for the fourth quarter of 1917 W. J. Musick, blacksmith foreman of the St. Louis shops of the Missouri Pacific R.R. wrote:

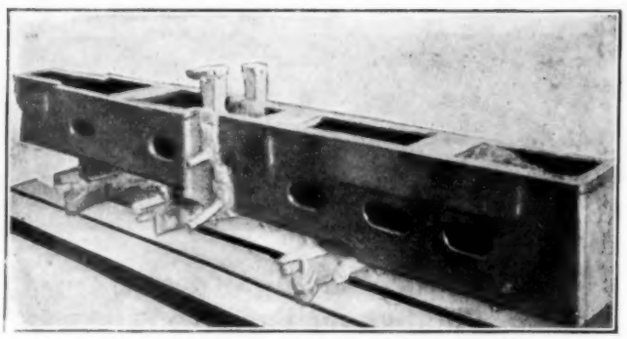


FIG. 77. CAST-IRON ROLLING MILL BASE REPAIRED FOR THE WACLARK WIRE CO., ELIZABETH, N. J.

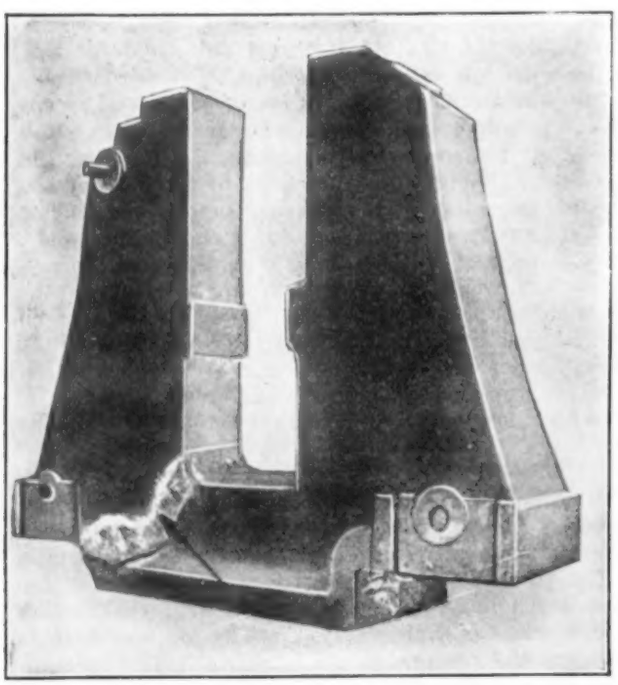


FIG. 76. WELD ON 48-IN., 68,000-LB., CAST-IRON BLOOMING MILL HOUSING. ABOUT 3500-LB. OF RAILROAD THERMIT USED

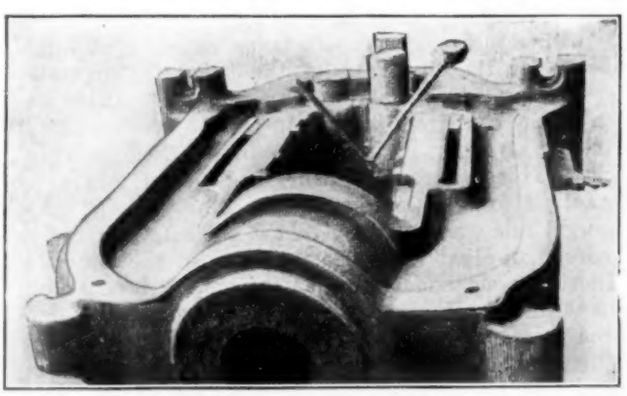


FIG. 78. REPAIR ON A 25-TON NAIL-MACHINE HOUSING

We recently had one of our steam hammers break through both sides of the frame and through the throat, the fracture being 61 in. long. This hammer was so badly broken that it seemed as though it were doomed for the scrap pile.

A new steam hammer was ordered, but in the meantime it was decided to try to repair the old one with Thermit. The weld was made and a successful repair was accomplished, resulting in saving a considerable amount of money.

We have also welded a cast-iron engine bed for the Helmbacher Rolling Mill Co. The bed of this engine is 32 in. high and 12 in. across the top. The mill was only shut down 24 hours while the repair was being made.

Master Mechanic George M. Stone, writing in the same publication, says:

I think your readers will be interested in the accompanying illustrations of Thermit welds which have been made by me in the shops of the Chicago, Rock Island and Pacific Railroad, Chickasha, Okla., and I would like to call par-

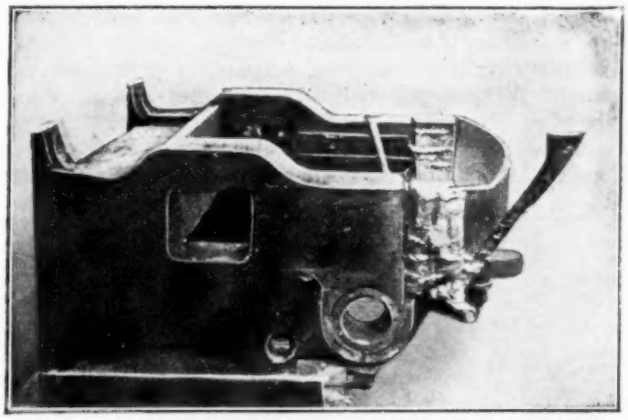


FIG. 79. CAST-IRON HOUSING OF KNUCKLE MACHINE, WELDED BY THE STANDARD PARTS CO., CLEVELAND, OHIO

ticular attention to the welding of valve seats on locomotive cylinders, which I consider an exceptionally good piece of work in view of the fact that these are cast-iron cylinders. The manner in which we handled the work was as follows:

The ports of the cylinders were cracked through from the steam port to the exhaust port. A Thermit weld was made on these cylinders, and in order to do this the entire cylinder was cut loose from the frame and smoke arch of the locomotive. The pistons were removed from the cylinders, as well as the cylinder heads both front and back. The cylinder was then preheated with a slow wood fire and welded with Thermit.

We have also had very good success with the welding of

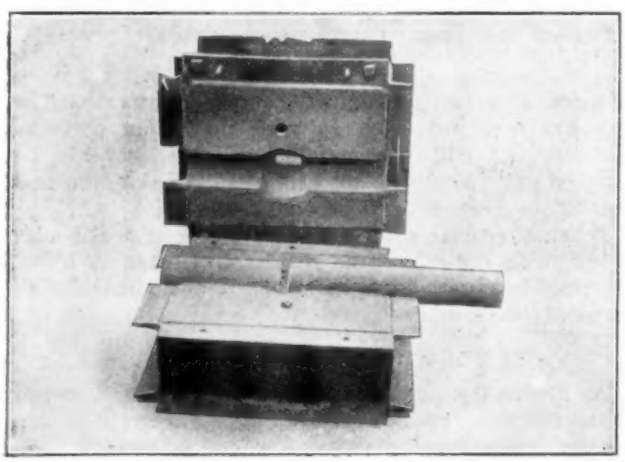


FIG. 80. MACHINERY STEEL AND HIGH-SPEED STEEL READY TO CLAMP MOLD

spokes in driving-wheel centers and the welding of main frames on one of our heaviest classes of engines in freight service.

These instances show that in many cases the success or failure of a cast-iron welding job is merely a matter of good judgment. As in other kinds of welds, expansion and contraction must be allowed for, and in many cases where a purely Thermit weld would be out

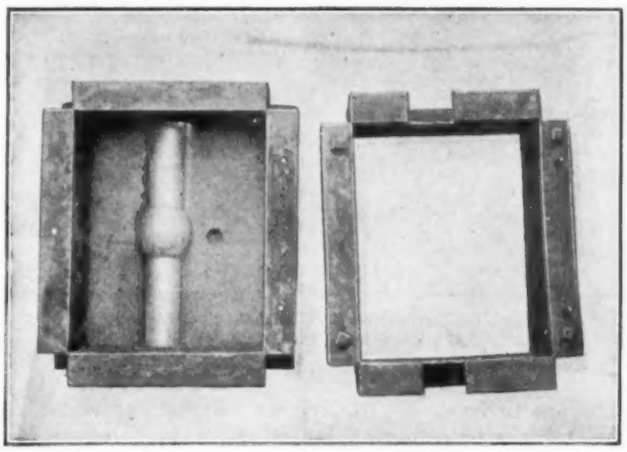


FIG. 81. SHEET-IRON MOLD BOX AND WOODEN PATTERN

of the question, owing to the difference in contraction of cast iron and Thermit steel, the Thermit may be used merely to bring the broken surface up to a fusing heat and then molten cast iron may be burned on, as was done with the shear jaw previously mentioned.

The illustrations here given show how Thermit welding may be applied to various cast-iron machine parts. Fig. 76 shows a weld on a 48-in. blooming mill housing, which weighed 68,000 lb. Approximately 3500 lb. of railroad Thermit was used. Fig. 77 shows a weld on a rolling-mill bed made for the Waclark Wire Co., Elizabeth, N. J. The weld shown in Fig. 78 was on a 25-ton nail-machine housing, and 650 lb. of Thermit was used. Another housing weld on a knuckle machine made by the Standard Parts Co., Cleveland, is shown in Fig. 79. Many times breaks on machine-tool parts could be repaired in the same way.

Welding High-Speed Steel to Machinery Steel

The largest weld ever made, up to January, 1919, was a cast-iron weld on a blooming-mill shear at the plant of the Pittsburgh Steel Co. The broken piece was of irregular shape approximately 37 in. wide by 5 ft. 6 in. long and weighed about 3000 lb. Five No. 10 crucibles were used for the job.

Sometimes it is advisable to weld tool or high-speed steel to a mild-steel bar or shank. This is perfectly feasible for special drills, reamers, boring bars or

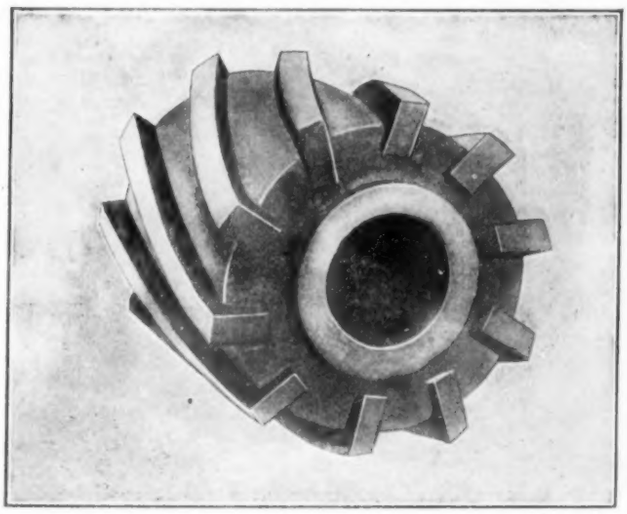


FIG. 82. HIGH-SPEED STEEL CUTTERS HELD IN WAX PATTERN WITH HOLLOW STEEL CORE

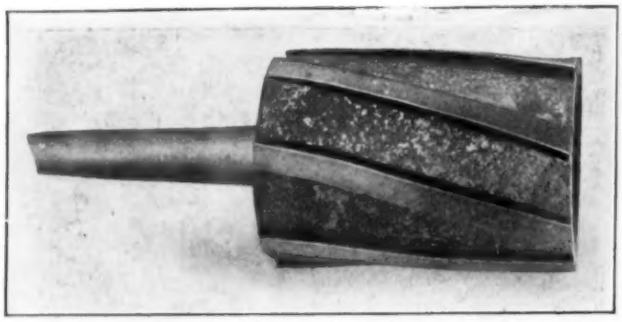


FIG. 83. HELICAL INSERTED-BLADE REAMER MADE BY THE THERMIT PROCESS

special tools of various kinds. Where only one or two jobs are to be done ordinary welding by the wax-core method may be employed, but where many pieces are to be welded it will pay to make molds. A mold for

TABLE V. COST OF THERMIT AND APPARATUS FOR GENERAL WELDING

	Gross Lb. Shipping Weight	Cost
Railroad Thermit (50-lb. boxes only)	67½	$17.50
Plain Thermit (50-lb. boxes only)	59	17.00
Cast-iron Thermit (50-lb. boxes only)	70½	17.50
Ignition powder (½-lb. cans)	..	.45
Yellow wax, per pound	..	.35
Punchings, per pound	..	.025
Special molding material (300 lb.)	340	4.00
Fire clay (300 lb. net)	340	3.50
Fire brick, per barrel (300 lb. net)	340	4.00
Kiln-dried silica sand (300 lb. net)	340	3.50
Single-burner preheater	200	50.00
Double-burner preheater	225	75.00
Flaming-burner attachment	...	3.00
Magnesia stones, No. 1	...	.15
Magnesia stones, No. 3	...	.20
Magnesia thimbles, No. 1	...	.10
Magnesia thimbles, No. 3	...	.15
Magnesia tar, about 400 lb. net	450	.06
Plugging material, No. 2 package	...	.10
Automatic crucibles (with caps and rings)	40	4.00
Automatic crucible, No. 2	60	5.50
Automatic crucible, No. 5	150	11.00
Automatic crucible, No. 10	775	60.00
Cast-iron relining cone, No. 1	50	5.00
Cast-iron relining cone, No. 5	150	12.00
Cast-iron relining cone, No. 10	600	40.00
Tripods, Nos. 1 to 7, weights 11 to 65 lb.	...	$2.50 to 9.00

welding round bars together is shown in Fig. 80. The pattern and mold box for this are shown in Fig. 81.

High-speed steel blades may also be welded into large or emergency job reamers in a comparatively short time. For this purpose a cylinder is bored out slightly larger than the hole to be reamed. The blades for the reamer are placed inside this cylinder and wedged into their proper places. Tin or wooden spacing pieces may be used for this if they are so placed as to be removed after the wax hardens. After the blades are fixed in position another cylinder or piece of pipe is centered inside the blades, allowing space between the blades and this cylinder according to the size of the reamer being made. Wax is next poured into the spaces between the blades and the inner cylinder. After it is removed from the outer cylinder and the wax hardens, enough of it is trimmed away between the blades to allow for chip space. The wax matrix with the blades in place is then rammed up in a mold. The inner cylinder is then warmed slightly and removed. A steel shank is next inserted and centered correctly. The wax is now melted out and the Thermit steel run in, welding the blades securely to the steel shank. A wax matrix, with blades and inner cylinder

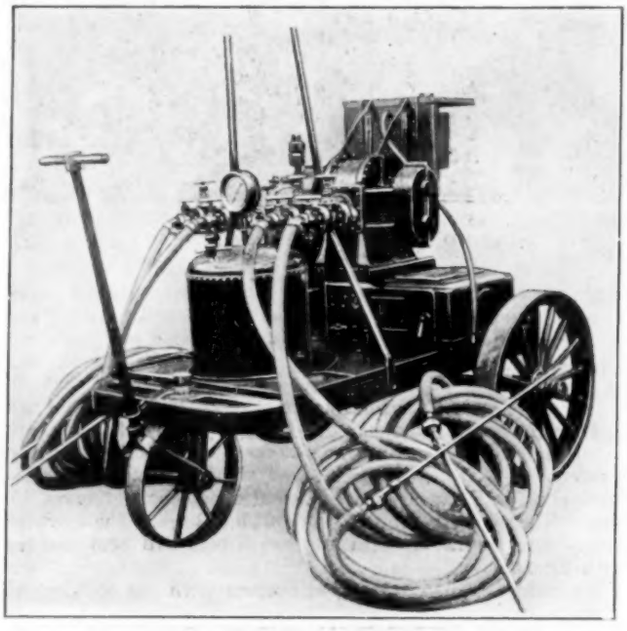


FIG. 85. RAIL PREHEATER THAT WILL HEAT FOUR JOINTS AT ONCE

in place, is shown in Fig. 82. In this illustration the wax has been cut away between the blades and the assembly is ready to be put into the mold box and be rammed up. When the work is cool it is centered and the blades ground for size and clearance.

A helical reamer with inserted high-speed steel blades is shown in Fig. 83. This reamer was made by T. O. Martin, blacksmith foreman of the Illinois Central R.R. shops at Jackson, Tenn.

Preheaters for Thermit Work

As practically all welds in ordinary practice, except those on pipe, require preheating it is well to use heaters made for the purpose wherever possible. In some shops gas-burning torches supplied with compressed air may be used. Many shops, however, have neither gas torches nor compressed air. This method is not practicable on outdoor welds. Crude-oil heaters should not be used at all, on account of their tendency to deposit carbon or other matter on the surfaces to be welded, thereby causing inperfect welds. In order to make the preheating work as easy and convenient as possible the Metal and Thermit Corporation makes the preheaters here shown. Fig. 84 shows two kinds,

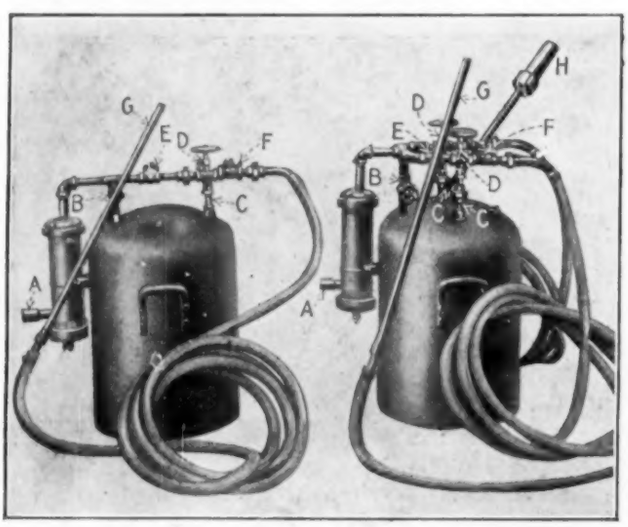


FIG. 84. SINGLE-BURNER AND DOUBLE-BURNER PREHEATERS, USING EITHER GASOLINE OR KEROSENE

a single and a double burner. For infrequent or small jobs the single burner, which may be fitted with a flaming burner also, will probably answer the purpose. Where a number of welds are to be made, however, the double-burner apparatus should be selected. In these illustrations *A* is the place to attach the hose from the compressed-air supply; *B* is the valve for regulating the pressure on the surface of the fuel; *C* is a tube which runs within a few inches of the bottom of the tank; *D* is the needle valve which controls the fuel to the burner; *E* is the air pressure control to the burner; *F* is a check valve which prevents back fire; *G* are torches or burner pipes; *H* is a flaming burner. The small tank on the left side is a water separator for the compressed-air supply.

Fig. 85 shows a four-burner portable apparatus used largely for rail-welding work. It carries its own air compressor, which may be run by attaching to a trolley wire or to some other electric-current supply. All of these burners use either gasoline or kerosene.

Cost of Thermit Welds and Apparatus

There are many factors which enter into the calculation of the cost of Thermit welding and the apparatus. Where a single weld is to be made and the shop man has to buy the apparatus, materials and do the work himself, the cost will naturally be higher than where several welds are to be made or where he can hire it done. There are so many places now making a specialty of Thermit welding that in ordinary circumstances it is usually better to have them do the work on large jobs than for inexperienced men to undertake the work. One big factor in favor of Thermit welding, on large jobs especially, is that of time saving, and many times this process would be preferable to any other plan on this account alone, even if the cost were ten times what it really is.

Data for the approximate cost of various jobs has been given in tables and specifications throughout the article, but in order to give those responsible for repair or other welding work, as exact information as possible on which to base their calculations, the accompanying tables are included. These are taken from the price list of the Metal and Thermit Corporation, published June 15, 1918, and of course are subject to changes. These quotations are f.o.b. Jersey City, N. J. Table V gives prices for general welding materials, and Table VI for pipe work. It will be noted that some of the quotations in this last table do not exactly agree with figures given in the table of comparative costs of Thermit welded and mechanically-joined pipe, but it should be borne in mind that the comparative table gives averages only, and is also subject to variations in cost of labor and materials.

TABLE VI. COST OF MATERIALS AND APPLIANCES FOR PIPE WELDING

STANDARD WEIGHT PIPE

Inside Diameter, Inches	Price of Welding Portions: 100 or Less	Over 100 and Less than 500	Over 500 and Less than 1000	1000 or More	Price of Mold	Price and Size of Crucibles		Price and Size of Tongs		Price and Size of Clamps		Price and Size of Pipe Facing Machines	
½	$0.36	$0.32	$0.27	$0.19	$0.75	No. 2		No. 2		No. 1		No. 1	
¾	.44	.40	.36	.26	.75	2		2		1		1	
1	.60	.56	.55	.39	1.00	2		2		1		1	
1¼	.78	.74	.69	.60	1.25	2	$1 75	2	$2.00	1	$20 00	1	$35.00
1½	.90	.86	.84	.75	1.50	2		2		1		1	
2	1.03	.99	.97	.90	1.75	2		2		1		1	
2½	1.50	1.46	1.43	1.35	2.00	3		3		1		1	
3	2.16	2.12	2.09	2.06	2.25	3	3.00	3	2.50	1		1	
3½	3.06	3.02	2.99	2.96	2.50	4		4		2		2	
4	4.63	4.59	4.56	4.50	2.75	4	4.75	4	3 25	2	25.00	2	60.00
EXTRA HEAVY PIPE													
½	$0.45	$0.42	$0.37	$0.29	$0.75	2		2		1		1	
¾	.54	.48	.42	.34	.75	2		2		1		1	
1	.72	.67	.62	.56	1.00	2	$1.75	2	$2.00	1		1	
1¼	.90	.86	.84	.75	1.25	2		2		1	$20.00	1	$35 00
1½	1.14	1.10	1.05	.98	1.50	2		2		1		1	
2	1.78	1.75	1.71	1.65	1.75	3	3.00	3	2.50	1		1	
2½	2.94	2.90	2.86	2.80	2.00	4		4		1		1	
3	4.23	4.20	4.16	4.10	2.25	4	4 75	4	3.25	1		1	
3½	5.43	5.40	5.36	5.10	2.50	4		4		2		2	
4	6.22	6.18	6.14	6.08	2.75	5	7.50	5	4.50	2	25.00	2	60.00
DOUBLE EXTRA HEAVY PIPE													
½	$0.93	$0.90	$0.86	$0.81	$1.50	No. 2		No. 2		No. 1		No. 1	
¾	1.08	1.04	1.02	.96	1.75	2	$1.75	2	$2.00	1		1	
1	1.20	1.16	1.14	1.08	2.00	3		2		1		1	
1¼	1.49	1.43	1.41	1.36	2.25	3	3.00	3		1	$20.00	1	$35 00
1½	2.14	2.08	2.03	1.94	2.50	4		3	2.50	1		1	
2	3.82	3.73	3.71	3.68	2.75	4	4.75	4	3.25	1		1	
2½	7.30	7.27	7.24	7.20	3.00	5		5		1		1	
3	10.60	10.57	10.54	10.50	3.50	5	7.50	5	4.50	1		1	

What Is the Matter With the Machine-Tool Business?

By Entropy

Just *why* anyone stays in the machine-tool business is almost as great a mystery as *how* they can stay in it. It is an absolutely essential business, and yet it is among the first to go down under pressure and the last to come up. What is the matter? Why cannot it be equalized?

Possibly the trouble is that a machine tool built just after the Civil War was almost usable at the beginning of the late war. In hardly any other line of machinery are the builders so lacking in inventive ability that they cannot change designs radically in less time than it takes to wear out the product. In the machine-tool business the changes in design over a period of 10 years are only noticeable to an expert. There may be a change in the style of oil-hole covers or there may be a handwheel on the tailstock instead of a crank, but the fundamentals remain imperceptibly changed. The size of the head spindle for a 16-in. lathe has advanced timidly by sixteenths of an inch. The change gears have hardly been glanced at, the belt power has mounted only by eighths. Our designers seem to be tied hand and foot; conservatism has held the fort, and timidity is the only recognized virtue. Once in a blue moon some designer from the back-hill country comes out, shines with meteoric splendor, makes a killing, grows rich and shuts up in his shell again. Such circumstances only accentuate the gloom; they do not light the way for others. Users of machine tools are apt to look on them as permanent investments, not as articles of consumption. Not long ago I sold a lathe to a shop where they were considering taking out an oldish machine with a stone bed. On reconsideration, however, it was decided that the old machine was pretty good for certain purposes and might as well stay. Can such a thing be imagined of any other kind of a machine? Very few new general-purpose machine tools have been

changed since the memory of the present generation enough to alter their identity. Very few special-purpose machines have developed a general demand.

One reason is that so few builders are willing to make changes from the standard article, and the product is so standardized that it is very expensive to make those changes. An entirely special machine not far different from the standard may easily cost four or five times the asking price for the standard machine. When built, used and sold again it will bring no more and possibly not as much as a standard machine that has been used as long. The purchasing public is not educated up to a sense of values. It is apt to figure back to a price per pound basis, whereas the basis should be earning capacity per dollar.

A machine that requires a $1500 man to operate it may only cost $1000 all set up and equipped. The overhead charges may be 200 per cent., which will make the total cost of operation $4500. Against this the original cost of the machine is a pretty small item. A new machine at the same price which will add 25 per cent. to the product will pay for itself in a year. It is pretty difficult to look into a machine shop and not imagine a 25 per cent. improvement in its equipment. It is more difficult to work in one and not imagine a 100 per cent.

Handiness Sought by Makers

Handiness is sought after by a few makers, but seldom referred to by the makers in their advertisements. Quickness of adjustment, of setting up, so that idle time is cut, is not always thought of. Someone proposed several years ago that there might be false planing-machine tables so that work could be set up on one, as on a bench, and the planing machine be cutting away on the other. It has even been tried out successfully, but never adopted. Gear boxes for quick change of thread cutting are popular, and yet lathes are used less than 5 per cent. of the time on thread cutting. They are a talking point, but not much more. It is such a job to get a vise off that most small shaping jobs not specially fitted to be held in a vise are done on a planing machine costing twice as much and taking twice as long. And so we might multiply instances of ways in which one who stands off at a little distance from the problem might add to the efficiency of the use of the machine without adding greatly to its cost.

All this will be of no value so long as the stereotyped phrases are in circulation, such as "If you are interested in obtaining only the best tools, etc.," "Insures accurate alignment and efficiency," "All bearing accurately scraped or ground to exact standards" and so on for ever. Something new will have to be used; something that indicates what percentage of the time a machine has to stand idle because of lack of adequate equipment of which the purchaser does not realize the need. If a dealer gets an order for a lathe and equipment he will send the customer a chuck and a set of 10 or a dozen lathe tools of carbon steel, and he stops right there instead of asking what the machine is to be used for and supplying a set of equipment suited to the job.

Salesmen will also have to quit using these same stock phrases, and will have to learn that a demonstration is the only convincing thing to a purchaser of a lathe or a milling machine just as it is with the purchaser of a grinding machine. The weakest built lathe in the country with proper equipment will beat out the best lathe with improper equipment on some classes of work. The improper equipment is almost sure to be the home-made type. Again, if the salesman could find out what type of work the machine was wanted for, he might often direct the attention of the purchaser to these accessories or to some special changes that could be made to make the machine more effective.

Unless some such timid advances are made by builders it seems likely they will continue in the feast-or-famine way in which they have gone for the past 50 years. The public must see visible signs of profit before it will swap horses and pay anything to boot. If there is a profit there never is a time so dull that there is not a group of firms which has always made its money by buying its straw hats in the winter and which has the cash hidden away for just such opportunities to buy before the other fellow does and beat him to it for the profits.

Spanish Equivalents for English Names of Metals in Common Use

By J. J. McIntyre

In view of the probable expansion of export trade, particularly in the direction of the Spanish-speaking countries of South America, a knowledge of Spanish nomenclature as applied to things intimately associated with the machine shop will not come amiss. As a step in this direction the following partial list is appended:

English	Spanish
High-speed steel	Acero para alta velocidad.
Oil-hardening steel	Acero templado con aceite.
Chrome and nickel steels	Acero al cromo y niquel.
Tool and drill steels	Acero para herramientas y taladros.
Pick, wedge and hammer steels	Aceros para picos, cuñas y martillos.
Music wire for springs	Alambre para resortes.
Cold-rolled steels	Aceros laminados en frio.
Forgings, specialties	Piezas forjadas especialidades.
Toolholder steel	Acero de porta-herramientas.
Vanadium steel	Acero vanadio.
Annealed punch and die steels	Acero recocido para punzones y matrices.
Spring steels	Acero para resortes.
Machinery steels	Acero para maquinaria.
Drill rods	Varillas de taladro.
Tempered spring wire	Alambre de resorte templado.
Drawn steels	Aceros estirados.
Iron	Hierro.
Steel	Acero.
Forged steel	Acero forjado.
Tool steel	Acero de herramientas.
Angle iron	Hierro de angular.
Forged iron	Hierro forjado.
Cast iron	Hierro fundido.
Wrought iron	Hierro dulce.
Brass	Latón.
Bronze	Bronce.
Copper	Cobre.
Gold	Oro.
Lead	Plomo.
Silver	Plata.
Tin	Estaño.
Tungsten	Tungsteno.
Crucible steel	Acero de crisol.
Openhearth steel	Acero siemens-martin.
Steel castings	Piezas fundidas de acero.
Pig-iron billets	Hierro en lingotes.
Steel plates	Chapasde acero.
Steel bars	Barras de acero.
Strip steel	Acero en tiras.
Seamless tubing	Tubería inconsútil.

Government Inspection of Machines and Small Tools

EDITORIAL CORRESPONDENCE

Some of the requirements of the War Department in the matter of inspecting machine tools, micrometers and similar products are of interest to those who desire to know what standards of accuracy are demanded by the War Department.

THE various machines and small tools purchased by the government must pass rigid inspection requirements, for which definite rules have been formulated. For lathes, after the usual visual inspection, the following tests are prescribed:

For Alignment of Live Spindle.—The lathe shall be levelled by means of a sensitive graduated spirit level laid on the tops of the ways. This must read the same when laid in any position across the ways at the two ends, or lengthwise at any point.

A test bar will be furnished the inspector by the Government. It will have a standard taper at one end and a cylindrical portion, one in. in diameter and about 12 in. long, extending therefrom. The tapered portion of this test bar will be used to gage the correctness of size and angle of the tapered hole in the end of the live spindle.

With the test bar inserted in the spindle, and an indicator mounted on the toolpost and set against the top of the bar, move the carriage and indicator out to the end of the test bar. The difference in readings between the two ends of the bar will give the error in alignment in the vertical plane. Without moving the carriage, rotate the spindle one half turn, or 180 degrees.

Move the carriage and indicator back to the head end of the bar. Rotate the spindle for a second half turn, or 180 deg. Note the difference in readings between the beginning and end of the latter movement. The indicator and spindle are now at their original positions.

Set the indicator on the side of the test bar, and without rotating the spindle, move the carriage and indicator out to the end of the bar. The difference in readings between the two ends of the bar will give the error in alignment in the horizontal plane.

Rotate the spindle through one half turn, or 180 deg. Note the difference in reading.

Move the carriage and indicator back to the head end of the bar. Rotate the spindle for a half turn, or 180 deg. Note the difference in readings between beginning and end of latter movement.

For Alignment of Tail Spindle.—With the indicator at the side of the end of the bar, and with the tail spindle flush with the front face of the tailstock, adjust the tailstock by a side movement so that it centers with the test bar in a vertical plane. Read the indicator.

Run the tail spindle out 75 per cent. of its length, and again center it in the test bar. Note the difference between these two readings.

The tail spindle must be clamped tight to the ways when each of these readings is being taken.

Move the indicator to the top of the test bar. Determine the difference in readings when the tail center is flush and when it is 75 per cent. extended.

For Truth of Cross Feed and Faceplate.—Note diameter of the largest faceplate.

Clean the threads on the large spindle, and screw on the largest faceplate covered by the order. Adjust the indicator on the toolpost so that readings may be taken across the horizontal diameter of this faceplate. By means of the cross feed and without rotating the plate determine the difference in readings between the front edge and the center of the plate.

Continue the motion, and determine the difference in readings between the center and rear edge of the plate.

Rotate the spindle and faceplate one quarter turn, or 90 deg. By means of the cross feed determine the difference in readings between the rear edge and center of the plate.

Continue the motion and determine the difference in readings between the center and front edge of the plate.

Obtain the signed statement called for by the specifications to the effect that the threads on the lead screw are within the limits of accuracy called for by the specifications.

TESTS FOR SHAPING MACHINES

In addition to the visual and operating inspection, the following tests are made for the accuracy of the machines:

1. Every machine shall be tested by the inspector after it has been tested and passed by the manufacturer. The manufacturer may observe all Government tests.

2. Adjust the machine so that the ways on the column are vertical, using a sensitive, graduated spirit level and square. See that the table top and the top of the vise body are level.

3. *Alignment of the table top with the line of motion of the ram.*—Clamp an indicator in the toolpost with its point against the top surface of the table near the outer edge. Move the ram back till the indicator makes contact near the inner edge of the table. The difference of these two readings gives the error in alignment of the table top with the line of motion of the ram. This must not exceed 0.003 in. in 12 in. of movement.

4. *Alignment of the table top with the line of transverse motion of the table.*—With the indicator still clamped in the toolpost, move the table till the indicator makes contact with the top surface first near one edge then near the other. The difference in the indicator readings gives the error in alignment between the table top and the line of transverse table motion. This must not exceed 0.003 in. in 12 in. This test is unnecessary if the table swivels.

5. *Alignment of the side of the table with the line of motion of the ram.*—With the indicator clamped in the toolpost, adjust its point to bear on the side of the table and make a test similar to 3. The error in alignment must not exceed 0.003 in. in 12 in. of movement.

6. *Alignment of the table when swiveled.*—If the machine has a swiveling type table, turn the table through 90 deg. and test the surface now on top for alignment as in 3. The error in alignment must not exceed 0.003 in. in 12 in. of movement.

7. *Alignment of the table side with the vertical motion of the table.*—Clamp the indicator on the table support or some part which does not move with the table and bring its point into contact with the side of the table. The difference in the indicator readings as the table is run up and down will show the error in alignment of the side of the table with the line of vertical motion of the table. This must not exceed 0.003 in. in 12 in. This test is unnecessary if the table swivels.

HORIZONTAL-SPINDLE MILLING MACHINES

In addition to the usual inspection, the machines are operated to see that they function properly, that gears run quietly, that friction clutches and releasing clamps act properly, that limits and safety stops perform their various functions, and that the machines generally are in good condition. The following tests for accuracy are then prescribed:

1. Every machine shall be tested by the inspector after it has satisfactorily passed the manufacturer's test. The manufacturer may observe all Government tests.

2. *Relation of the table top to the vertical motion of the table.*—Set the machine so that the ways on the column are vertical. Use a sensitive, graduated spirit level with a square to determine when this condition has been obtained. With the machine set so that the column ways are vertical, test the table to see that it is level in all directions.

3. *Size of the taper hole in the spindle.*—Test the taper hole in the spindle. See that the diameter, length and taper of the hole are correct.

4. *Alignment of the taper hole in the spindle with the spindle bearings.*—Insert a test bar in the spindle. Clamp an indicator on the table so that it may be brought into contact with the test bar near its end. Turn the spindle and note the maximum and minimum readings of the indicator. Their difference must not exceed 0.002 in. Repeat the test with the indicator in contact with the test bar about 1 in. from the spindle nose. A tolerance of 0.001 in. is permitted.

5. *Vertical alignment of the spindle with the transverse motion of the table.*—With the indicator clamped on the table, bring it in contact with the bottom of the test bar about 1 in. from the spindle nose. Without turning the spindle, move the saddle so that the indicator moves over the length of the test bar. In order to eliminate errors due to non-alignment of the spindle hole with the spindle bearings, turn the spindle through 180 deg. and return the saddle and indicator to the spindle end of the test bar. The movement of the indicator needle must not exceed 0.002 in. in 12 in. of movement.

6. *Horizontal alignment of the spindle with the transverse motion of the table.*—Set the indicator against the side of the test bar instead of the bottom and test for alignment in a horizontal plane in a similar manner to that described in 5. The limits of error in alignment are the same as those in 5, 0.002 in. in 12 in. of movement.

7. *Alignment of the table top with the tranverse motion of the table.*—Clamp the indicator on the spindle or some part which does not move with the saddle or table and bring it into contact with the top surface of the table. Move the saddle so that the indicator traverses the table top. The indicator readings at the opposite edges of the table will show the error in alignment between the table top and the transverse motion of the table. This must not exceed 0.002 in. in 12 in. of movement.

8. *Alignment of the table top with the longitudinal motion of the table.*—With the indicator clamped as in 7, bring it into contact with the top surface of the table near one end. Move the table so that the indicator travels the full length of the table. The indicator readings at opposite ends of the table will show the error in alignment of the table top with the longitudinal motion of the table. This must not be more than 0.002 in. in 12 in. of movement.

9. *Alignment of the table swiveling motion with the table top (on universal millers only).*—On universal millers, swivel the table as far as possible and repeat the alignment tests for longitudinal and transverse table motions, 7 and 8. The tolerance are the same, 0.002 in. in 12 in. of movement.

See that the swivel table clamps hold the table firmly.

10. *Size of the taper holes in the spiral head and tailstock.*—Test the taper hole in the spiral head and tailstock with the test bar furnished for that purpose to see that the holes are of correct diameter and taper.

11. *Alignment of the taper hole in the spiral-head spindle with the spindle bearings.*—Make a test on the spiral-head spindle similar to the test for the main spindle described in 4. The tolerances are 0.002 in. at 12 in. from the spindle nose, 0.001 in. at 1 in. from the spindle nose.

Cylinder Grinding Machines

The visual and operation tests are very similar to those of the milling machines, with regard to gears meshing properly and speed stops acting positively. The accuracy tests are as follows:

Mount an angle plate with a true, flat face on the table facing the end of the wheel spindle. Mount an indicator on the wheel spindle with its point in contact with the face of the angle plate. Set the angle plate so that rotating the head without turning the spindle will show the plate aligned with the plane of rotation of the end of the wheel spindle within 0.002 in. in 12 in. The spindle should be set for boring the maximum hole, that is, at its greatest eccentricity. If the plate is not accurately aligned, allowance should be made in the following tests for the error in setting up the angle plate.

Horizontal Alignment of the Table Motion with Spindle Rotation.—Clamp a square on the face of the angle plate with its blade parallel to and in the same horizontal plane with the wheel spindle. Adjust the indicator to read the alignment of the edge of the square when the table is moved parallel to the spindle. The error in alignment must not exceed 0.003 in. in 12 in. of movement.

Vertical Alignment of Table Motion with Spindle Rotation.—Repeat this test, but with the square in the same vertical plane as the spindle. The tolerance is 0.003 in. in 12 in. of movement.

Inspection of Micrometers

The inspection of micrometers involves the placing of the instrument in a stand so that it will not be necessary for the hand to come in contact with the frame while making the tests. The smoothness of the screw action should be noted and the adjustments made from zero. The measuring spaces are tested for accuracy by using hardened steel balls of different sizes, mounted in sheet aluminum handles. These should be used in order starting with the smallest ball. The judgment of the inspector must be used in rejecting micrometers which show high spots of lack of parallelism between the faces. The tests are as follows:

Make a light setting on the ball and then explore the surfaces of the measuring faces.

1. For micrometers reading from 0 to 1.0 in., test the following readings by means of Johannsen blocks—

Series A:—0.000 in., 0.200 in., 0.400 in., 0.600 in., 0.800 in., 1.000 in.

Series B:—0.000 in., 0.205 in., 0.410 in., 0.615 in., 0.820 in., 1.000 in.

Series A will check the screw and the zero on the sleeve at six points in the working range. *Series B*, when compared with the corresponding ones in *Series A*, will test the accuracy of the graduations on the sleeve.

2. Micrometers reading through another range, as from 2.0 in. to 3.0 in., from 3.0 in. to 4.0 in., etc., shall be tested through the working range in the same way, special attention being paid to the even inch measurements.

Check carefully the standards furnished with the micrometer.

3. *Tolerances.*—For micrometers reading to 0.001 in., the graduations, as tested in paragraphs 1 and 2, shall be correct within 0.0003 in. Micrometers reading to 0.0001 in. shall be submitted to the Bureau of Standards for test when so directed by the Supplies Inspection, Signal Equipment, Washington.

Turning Versus Grinding

By E. H. Fish

A cylindrical grinding machine to handle work of a certain size will cost from two to three times as much as a lathe of the same capacity. The cost of power is larger; the cost for oil and coolant is greater; the labor cost per hour may be a shade less.

Why not stick to the lathe? There are a number of jobs where accuracy cannot well be attained except by grinding, but the greater number of lathe jobs can be finished by a man of medium attainments on a lathe within the limits prescribed. Yet despite some of its well known limitations the grinding machine is gradually pushing its way in and growing more and more established as a standard and expected machine tool.

One very good reason for this is something which is peculiar to the grinding machine, but need not be, and that is the automatic-measuring feature. A grinding

machine operator micrometers his work, finds it is still 0.008 in. over size, sets his automatic-feed stop and quits worrying. It will not go under size anyway. It is this matter of measuring which is the fundamental difference between a skilled and an unskilled workman. A man who cannot measure at all must be a laborer; a man who can make fine measurements can have any job he likes in the mechanical field. When he makes fine measurements by aid of artificial means, by means of micrometers, automatic stops, or even unit pieces as a printer does, he is not really making the fine measurements himself, and he is not entitled to pay.

Another thing which makes the grinding machine profitable is that its cutting tool is self-sharpening; that is, each particle of abrasive cuts until it is dull and then it is pushed out of its matrix to make way for another sharp one. This is what should always happen and does happen if the wheel, its speed, the speed of the work and the material, are all suited to each other. If the operator is on day rates he welcomes a hard wheel which holds its shape and requires but little truing. It may need frequent dressing, but he does not do it. His production is low, but he claims that the time saved from truing makes up for the slow production. His machine is running a large portion of the time anyway, and unfortunately a great many foremen judge their men by the appearance of being busy rather than by production.

Put this same man on piece work and he soon calls for a softer wheel, one that cuts freely and wears down rapidly. Such a wheel is a source of profit to the makers, for two will be used where but one of the harder wheels would be required. To be sure the man with the soft wheel will get out double the product and more, so the superintendent has to figure very carefully to know just which wheel is the cheapest in proportion to production. A hard wheel lasts longer and stops less for truing the machine. A soft wheel produces more work, but requires more time for truing, less for dressing. It wears itself out quicker, but takes less power to run it. The superintendent needs a formula of this sort:

Cost of work = Cost of labor + cost of power + cost of wheel per unit + cost of truing + cost of dressing + general overhead.

Truing and dressing should be carefully distinguished. Truing is done to keep the wheel round and to preserve the shape of the face. Dressing is breaking up the face to knock out the dull particles of abrasive; in other words, dressing is sharpening.

Dressing is automatic if the wheel is of the correct grade. If the wheel is too hard, the cutting points dull and are rounded over, but do not fall out on contact with the work. It requires a dresser to knock them out. The dresser also knocks out a great many more sharp particles than it does dull ones. It is expensive medicine, but it must be used if a penurious purchasing agent persists in buying grinding wheels for their lasting qualities.

If the wheel is too soft the cutting particles will fall out before they have done their full duty. A too soft wheel is apt to wear out of true and require frequent truing. Efficient grinding can only be attained by scientific investigation. A man who claims to be able to tell by the looks of a wheel whether it is the best for a given job is taking advantage of the extreme ignorance of his customer. He may be able to improve the output by reason of the wheel formerly used being altogether unsuited for the job, but he cannot get the best conditions except by patient trial of different grades, grains and speeds.

Every test shows the direction in which to go. There is nothing blind about it. If the wheel is too hard the amount of work it will do will show a rapid decrease after the first few minutes, and its efficiency will be restored by dressing. If the grain is too fine there is no room for the chips and the wheel will clog and scratch the work. If the wheel speed is too slow there are not enough cutting particles presented to the work. If the work speed is too slow, production will be correspondingly slow. Speeding up a wheel that is too soft has the same effect as using a harder wheel, but the grade of wheel which most nearly approximates the requirements should be selected first and the work speed used to bridge the gap between the grade of one wheel and another of the same nominal grade.

The purchaser should realize that wheels of a given grade are not always uniform in hardness. Grade M means a range of grades that run into L and N on the hard and soft sides. Two M wheels may be quite a bit different in grade and still be graded correctly. The one which is nearly hard enough to be called L might be graded L by another grader. The same is true on the side toward the soft wheels. So there is need of means for varying the work speed so that all kinds of wheels of a given grade can be used to their greatest advantage.

Cutting Stub-Tooth Gears With a Standard Involute Cutter

By Joel Sundell

On account of the delay in obtaining replacements for gears and the consequent slowing up of production it was decided to take a chance and attempt to cut 20-deg. angle stub-tooth gears with a 14½-deg. angle standard involute cutter. That the chance was worth taking is shown by the fact that the gears so cut have operated for several months in just as satisfactory a manner as the original ones.

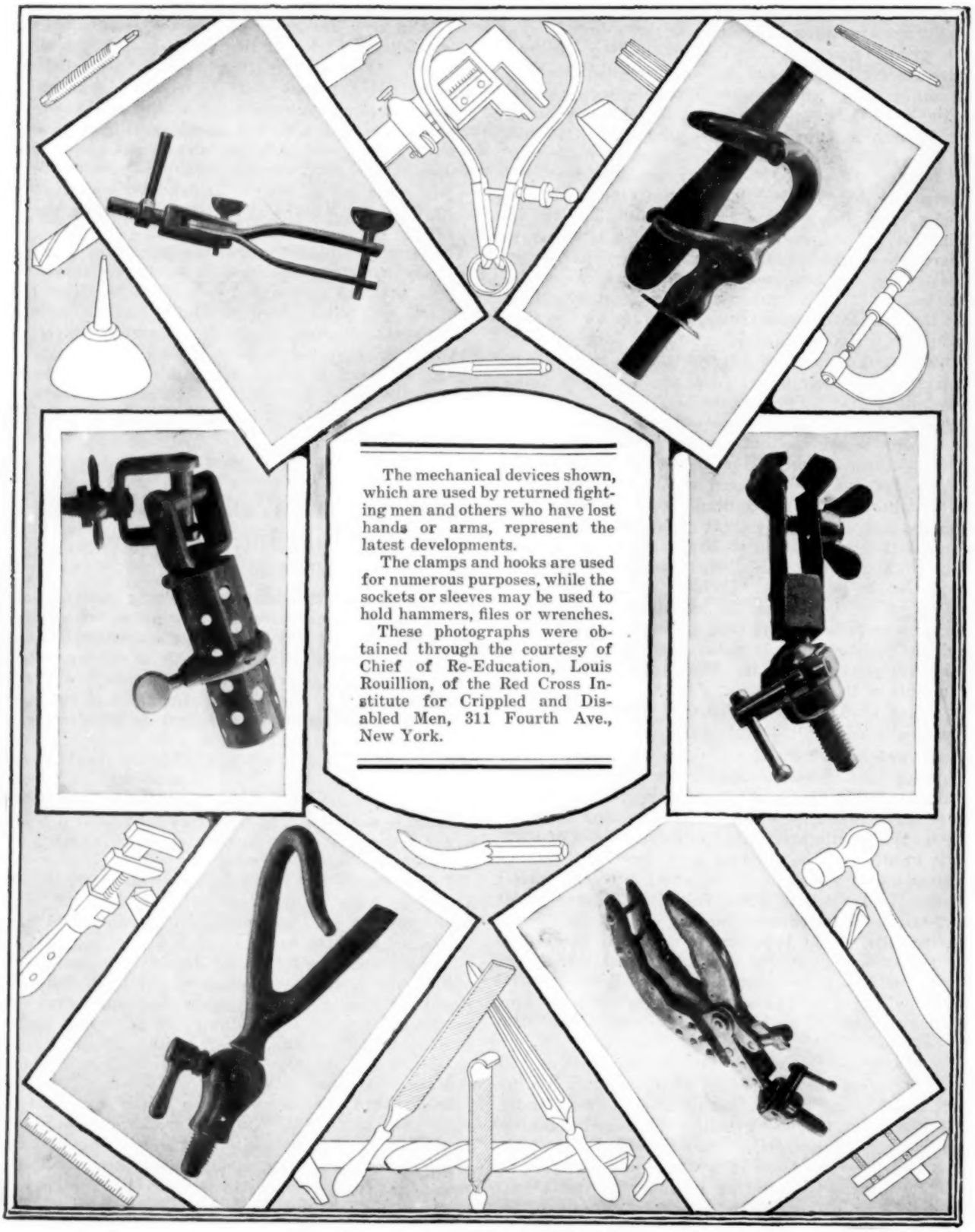
In attacking the problem a 10-pitch standard involute cutter was selected for an 8-10-pitch stub-tooth gear. On account of the differences in the two kinds of teeth it was decided to try either a No. 1 or a No. 2 cutter regardless of the number of teeth. Both gave satisfactory results in service.

To find the amount to set the cutter off center to give a 20-deg. angle we deducted 14½ deg. from 20 deg., which gave 5½ deg., and multiplied the sine of 5½ deg. by the radius of the work.

The job was done by setting the cutter on center and milling the teeth to the required depth all the way round the blank. Then the cross-slide was moved the determined amount to get the cutter off center and a shaving cut off one side of each tooth. The gear must be revolved in the opposite direction to that in which the cross-slide was moved, i.e., if the cross-slide was moved toward the column the top of the gear must be revolved away from it. Then the cross-slide was moved to the other side of the center and a shaving cut off the other side of each tooth, taking care to keep the thickness of the tooth at the pitch line correct. This may be tested with a solid gage or by a tooth caliper.

Mechanical Hands and Arms

BY J. A. LUCAS



The mechanical devices shown, which are used by returned fighting men and others who have lost hands or arms, represent the latest developments.

The clamps and hooks are used for numerous purposes, while the sockets or sleeves may be used to hold hammers, files or wrenches.

These photographs were obtained through the courtesy of Chief of Re-Education, Louis Rouillion, of the Red Cross Institute for Crippled and Disabled Men, 311 Fourth Ave., New York.

Suggestions for Conserving Coal and Assisting Manufacturing

By GEORGE N. COLE

This shows what was accomplished in coal conservation through instruction in burning fuel. It also suggests ways and means of spreading knowledge of the mechanical industries in the same way as agricultural pursuits are benefited by the present Government organizations.

THE Bureau of Conservation of the United States Fuel Administration did much effective work in saving fuel that should not be lost to the community, and it is the purpose of this article to indicate how this work may be advanced for the benefit of all concerned. In an address before the American Society of Mechanical Engineers at its recent annual meeting Davis Moffat Myers, representing the Fuel Administration, outlined that part of the work of the Bureau of Conservation which had to do with maintaining production at its highest rate with the minimum consumption of fuel.

He drew particular attention to the fact that the bureau strove for economical production rather than curtailment, and the slogan was "maximum of production with minimum of waste"; he also pointed to an accomplishment of saving coal that amounted annually to 7,000,000 tons and which it was expected to better greatly.

For an initial performance it was most striking and is worthy of perpetuation. It was accomplished in a prompt and simple manner. Avoiding the delays of survey with its inspections and reports the bureau went direct to the core of the matter by issuing a questionnaire which indicated what should be performed along eight divergent lines of factory economy. It asked owners what their operating conditions had been and suggested that they make all possible improvement in order to conform to the rules for conservation laid down by the bureau.

Substantial Fuel Savings

The response was prompt and the improvement began immediately and quickly mounted to a saving, as Mr. Myers states, of 10 to 25 per cent. in fuel. This is almost revolutionary and was accomplished not only in small plants but in the large ones. Factory interests were instructed to help themselves, and they have so appreciated the advantages that letters have been received in Washington from individual plants all over the country which say in effect, "We have installed your recommendations. Our records for the three months during which these have been in effect, compared with last year's three months, show a saving of 25 per cent. in fuel."

Results like these must be recognized for the general good and should not be abandoned. Little wonder that Mr. Myers reports that the closing of the activities of the Fuel Administration is met with the earnest question, "You are not going to let the fuel-conservation movement stop, are you? It has done us so much good you have got to go ahead with it."

At present the Bureau of Mines and the United States Geological Survey are taking over the work of improving the quality and the processes of mining. They are also considering the engineering problem of generating electric power near the sources of coal supply. Increasing the productivity of the individual plant on the same or reduced coal allowance is most important, but seems still in abeyance.

Utilizing the State Colleges

This calls to my mind a project I instituted in the winter of 1911 in one of our big manufacturing states. Moved possibly by envy of the facility with which the farmer can obtain detailed instruction in his various activities, whether they be of the soil or seed, animals or machinery, and that the investigating resources of the whole country are placed at his disposal by a postal card, attention was called to the fact that practically no aid was vouchsafed the manufacturing industries in any of the technical difficulties that arise from time to time. It was pointed out that this work might be done by the mechanical and other departments of the large state universities and the Government land-grant colleges, and that it would have the advantage of giving the student, under the supervision of the professor, a taste of the practical questions of manufacturing. After some trade-paper publicity and the energetic action of a state senator the State University of his commonwealth was put in possession of the ability and an appropriation to carry out work of this kind. Numerous land-grant colleges in the other states are doing various phases of this work to the great benefit of their manufacturing communities and inestimable advantage of the students participating.

This action was but the prewar manifestation of what could be slowly accomplished for the good of any manufacturing commonwealth. It was coming gradually into favor. As experience and publicity brought it to the aid of one plant competition and progress demanded its use by others. For some installations it had accomplished wonders—it had become a necessity.

Experiment Stations

With the urge and bustle and yet deficiencies of war production, patriotism demanded larger outputs with smaller supplies of power, men and material, and the country was obliged to develop its brains that its means might reach farther. One of these progressive organizations was the Fuel Conservation Bureau, and with keen, quick action it made our fuels cover their necessary obligations of doing more work per ton mined and at the same time vindicated the theory that the state benefits amply by leading and instructing its manufacturers.

Experiment stations have been tried before. More than a third of a century has vindicated the vision of

those who established the system of agricultural experiment stations throughout the country. These experiment stations had brought immeasurable recompense for the expenditure involved and no element in the community, not counting the directly interested farming industries, would see the activities of these stations impeded. They are in close relation to the agricultural departments of the land-grant colleges and have sprouted and branched into all the remotest parts of our country's earth, air and water plant products.

The Land-Grant Colleges

The land-grant colleges were founded for "the propagation of the agricultural and mechanic arts, not excepting military science." The last few years have proved that, as in military science, by their output of aviators, radio men and auto divisions, the people are in thorough touch with these universities, which are among the largest in the land, as to agriculture and military science mentioned above. Yet, with few exceptions, the mechanical departments of these schools still hold themselves apart from the communities they might serve so admirably.

The land-grant colleges and the agricultural experiment stations are today receiving large appropriation and support from the United States Government in addition to the goodly sums that the states find most profitable to bestow for the education of their sons and daughters, and they are most completely in touch with the agricultural interests and are bending their energies most seriously to their help. People and college would regard any curtailment as a catastrophe.

Helping the Mechanical Industries

The mechanical side of a state's industries should have equal benefit of a similar installation of experiment stations. As a Government enterprise it may be an innovation, but its benefits in a limited way under state supervision have already been proved, and it has the magnificent precedent of the before-mentioned chain of Government agricultural experiment stations, which extent from Maine and Florida to Alaska and the Philippines. State industrial extension stations, in connection with the mechanical departments of the various state schools now supported in part by the Government, could answer the questions and point progress, advise economies and teach administration to the industrial commonwealth similar to that the agricultural commonwealth now receives.

These mechanical stations could be coördinated, prevented from costly duplication and directed to new endeavor by a national bureau. This would provide a rational residuary legatee of the fuel-conservation work, a thing which Mr. Myers, the advisory engineer of the bureau, seconds, pledging in a letter that we may be sure of his "support of this excellent plan."

It is a movement that must be started promptly, that the impetus given to the work already under way may not be allowed to lag and because any delay is so much waste of real money to the industries. These industries are ready and anxious for guidance, and the opening should not be neglected. It is a proposition that is live today and 10 years from now it could no more be taken from the mechanical industries than its agricultural counterpart could be abolished today.

Fuse Sizes for Industrial Motors

Special Correspondence

The proper size of fuse for a motor is too often obtained by the chief electrician or one of his repairmen by haphazard methods. The motor's normal operating current is given by the maker on the name-plate, but fuses are properly selected of a larger capacity to allow for starting and for momentary overloads. Hence it is rather more usual for the maintenance man to select his fuses "be guess and be gosh," with a view to their permanence in service rather than the safety of the motor they are supposed to protect.

In order to give a practical working idea of what sizes to use, the Westinghouse Electric and Manufacturing Co. has prepared and issued the following tables. These are based on the following assumptions as to size of fuse required to stand starting current without blowing:

Type	Times Fuse Load Current at Starting
Polyphase wound rotor	1¼
Squirrel cage (thrown on line)	3
Single-phase repulsion induction with rheostat	2
Single-phase repulsion induction, without rheostat	4
Direct current	1¼

Since the fuses for squirrel-cage and repulsion motors without rheostats are respectively rated at three and four times full load current, they give practically no overload protection. Hence it is recommended that double-throw switches be installed connecting the motor through fuses of one and a quarter times full-load rating (as under wound rotor sizes) for running and through the regular heavier fuses or direct to the line for starting.

FUSE RATING IN AMPERES

Direct Current Motors

Hp.	Voltage 115	230	550
1	10	5	3
1½	15	8	3
2	20	10	5
2½	25	12	6
3	30	15	6
3½	35	15	6
5	50	25	10
6½	65	35	15
7½	70	35	15
8½	85	45	20
10	90	45	20
11	100	55	25
12½	110	60	25
15	125	70	30
20	175	90	35
25	225	110	45
30	275	125	55
35	325	150	65
40	350	175	75
50	450	225	95
60	550	...	110
75	...	...	150
100	...	...	200

2-Phase Wound Rotor Induction Motors

Hp.	Voltage 220	440
5	20	8
7½	25	15
10	35	20
15	45	25
20	60	30
25	70	35
30	90	45
35	110	55
40	120	60
50	150	70

3-Phase Wound Rotor Induction Motors

Hp.	Voltage 220	440	550
5	20	10	8
7½	30	15	12
10	40	20	15
15	50	25	20
20	70	35	30
25	85	40	35
30	100	50	40
35	125	60	50
40	150	70	60
50	175	80	65

3-Phase Squirrel Cage Motors

Hp.	Voltage 110	220	440	550
½	12	6	3	2
1	20	10	5	4
2	35	20	10	8
3	50	30	15	12
5	90	45	25	20

2-Phase Squirrel Cage Motors

Hp.	Voltage 110	220	440
½	10	6	3
1	20	10	5
2	35	15	10
3	45	25	15
5	80	40	20

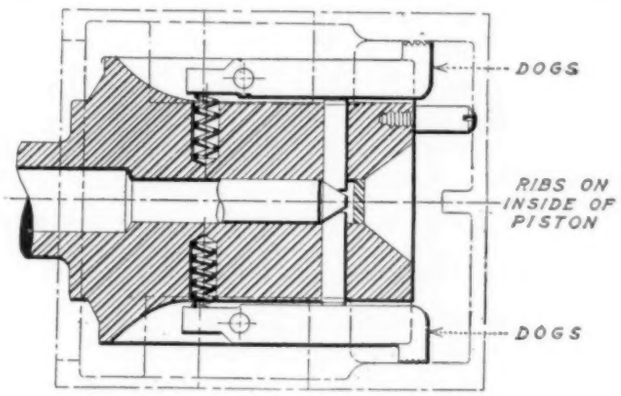
TYPE AR SINGLE-PHASE MOTORS

Hp.	Without Rheostat Voltage 110	220	With Rheostat Voltage 110	220
2	80	40	40	20
3	120	60	60	30
5	200	100	100	55
7½	325	175	175	80
10	400	200	200	100
½	20	10	10	6
¾	30	15	15	8
1	40	20	20	10

Air-Operated Chuck for Pistons

By Robert Belmont

In machining a piston which had ribs on the inside of the head running part way down in a parabola shape, we had considerable trouble due to the fact that we could not get up near enough to the head with the regular design of expanding chuck to prevent chatter-



CHUCK FOR GAS-ENGINE PISTONS

ing. After several attempts we developed the design shown in the sketch, which consists of a machine-steel body carrying expanding pins in the front end operating on four dogs which go up against the piston, forming a stiff and rigid method of holding. The chuck is used on a Bardons & Oliver lathe and is operated by air pressure.

An Automatic Blueprint Washer

By M. H. Potter

A unique device for washing blueprints is shown in Figs. 1 and 2. It consists of a stationary box or tray *A* having pivoted on it a smaller tray *B*, the bottom of which is composed of light slats. On this second tray, so attached as to be removable, is a smaller box *C* with a perforated bottom and divided longitudinally through the center by a partition.

The operation of this device is as follows: The top box being removed by turning the buttons securing it, the blueprints are laid on the slats of the second box, as many as six or eight at one time, and the top box replaced. The water is turned on at the faucet and one side of the pivoted box is depressed to either of the positions shown by dotted lines in Fig. 2, which will allow the water to flow into the compartment at the higher side of the smallest box. A considerable portion of the water will trickle through the small holes in the bottom of this box and onto the prints, while the opposite edges of the prints will be immersed in the water in the lower box, which is maintained at a constant level by the overflow. The perforations in the

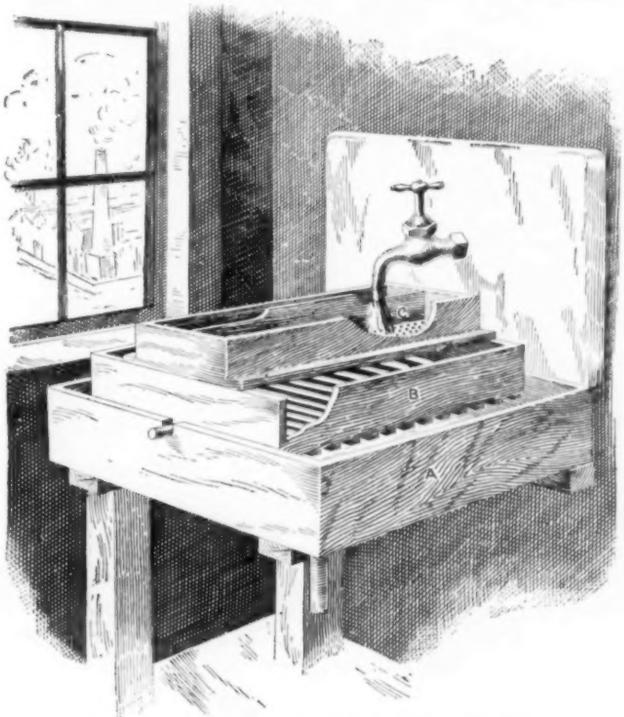


FIG. 1. AUTOMATIC BLUEPRINT WASHER

bottom of the top box not being sufficient to carry off all the water, it gradually fills up that compartment, and the pivoted box, thus overweighted, changes to the second position.

The water from the faucet now flows into the other compartment of the top box until this fills up and the operation is repeated. The frequency of the alternat-

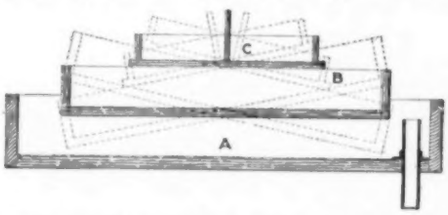


FIG. 2. HOW THE WASHER OPERATES

ing movement may be regulated by the amount of water allowed to flow from the faucet. The washing is very thorough as the prints lying on each other are separated and the upper ones float whenever that side is depressed

into the water. The water constantly flowing in and out of the lower box quickly eliminates the chemicals. Galvanized iron or zinc boxes protected by paint are preferable, although wooden boxes may be used if they are kept well painted.

Record of Chain and Sling Tests

By A. T. Miller

In the factory of the R. & V. Wagner Ordnance Co., East Moline, Ill., all chains and slings used for handling material are subjected to a monthly test to insure

TEST OF HOISTING CHAINS AND CABLES			DATE	DATE	DATE	DATE	DATE	DATE	DATE	DATE
			10-1-18	11-5-18	12-17-18	1-8-18				
SKETCH	NO.	TYPE	TEST	TEST	TEST	TEST	TEST	TEST	TEST	TEST
	1	BUFFALO SCALE	6000	7630	8040	11,080				
	2	SPREADER	7660	"	"	"				
	3	CABLE FOR SPREADER	"	"	"	"				
	4	CABLE FOR SPREADER	"	"	"	"				
	5	SPREADER	"	"	"	"				
	6	CABLE FOR SPREADER	"	"	"	"				
	7	CABLE FOR SPREADER	"	"	"	"				
	8	SPREADER	"	"	"	"				
	9	TWO CHAIN LIFT	5360	4880	4020	"				
	10	TWO CHAIN LIFT	"	"	"	"				
	11	FOUR CHAIN LIFT	7890	7530	8040	"				
	12	STEELCHAIN	"	"	"	"				
	13	STEEL CHAIN	"	"	"	"				
	14	CABLE SPREADER	"	"	"	"				
	15	HOOK SPREADER	"	"	"	"				

CHART OF CHAIN TESTS

safety to operatives and work when handling heavy pieces.

The results of these tests are noted on the chart, which is at all times available for inspection so that there is no excuse for imposing on any such part a burden greater than what is positively known to be a safe load.

A Timekeeper's Time Saver

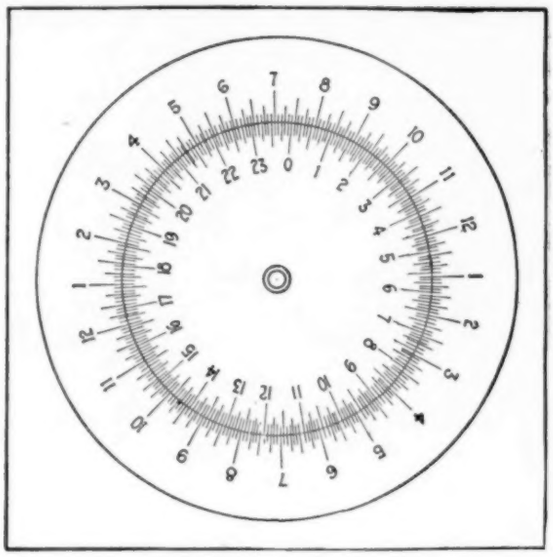
By Franklin H. Decker

The figure illustrates an easily constructed device for the rapid solution of problems in time calculation. The size depends upon the convenience of the user. The one shown was made of celluloid backed with heavy cardboard to stiffen it enough to make it durable.

Each circle has 288 small divisions, each representing 5 min., with every third dividing line made slightly longer to indicate a quarter hour. The longer lines are hour lines and are numbered from 0 to 23 in the inner circle and from 1 to 12 twice on the outer one.

The disk is shown set for the solution of a typical time problem. If a man comes to work at 7:25 and quits at 3:10, how many hours has he worked? The zero of the inner circle is set opposite 7:25 on the outer; then opposite 3:10 on the outer we read 7 hours 45 min. on the inner. If the man had had 20 min. for his lunch the first setting would have been at 7:45 and the total tim would have been 20 min. less, or 7 hours 25 minutes.

The disks may be divided in any other way suited to



TIME-COMPUTING DISK

the timekeeper's system. For finding the number of days between two dates the disks should be divided into 365 parts each and each fifth dividing line on the larger from 0 to 30 made longer. Leave a space for 31, mark this month January, begin over again at one for February and continue for the other months. Should Feb. 29 of a leap year come in between the given dates a day must be added to the indicated total.

Using Rimless Cartridges in New Service Revolvers

By E. A. Dixie

There is an interesting little story behind the article under the above caption on page 859, Vol. 49.

Several years ago the superintendent of one of the small-arms factories conceived the idea of making a clip to hold six cartridges to be used in the regulation revolver. My recollection of the clip is shown in Fig. 1. It is practically the same as the one shown on page 860, but holds six cartridges instead of three, and besides is provided with slots *A* in the members between the cartridges to provide a spring hold on the cartridges. The idea occurred to the inventor previous to the war. He made several of the clips, altered a revolver so as to use them and found that after a little practice he could fire more shots a minute with it than with the automatic pistol.

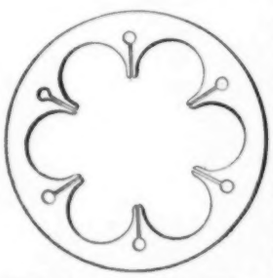


FIG. 1. THE ORIGINAL CLIP

However, there was apparently no demand for the device, and not finding a purchaser he swapped it for a second-hand automobile.

I do not know how many shops have been making the new-type clips, but I do know that they have been made by the million.

The stock used is a hard, cold-rolled steel strip 0.038 in. thick. The dies are made as shown in Fig. 2. Each die is made of two pieces of steel *A* and *B* to facilitate manufacture. The punches are made of a single piece of steel. Two dies are mounted as shown at *C* and *D*

and after the first stroke of the press two clips are made at each stroke.

The presses are run at about 160 strokes per minute. Owing to the very hard stock used the noise made by the presses is deafening. It was thought that the dies did not stand up as long between grindings as they

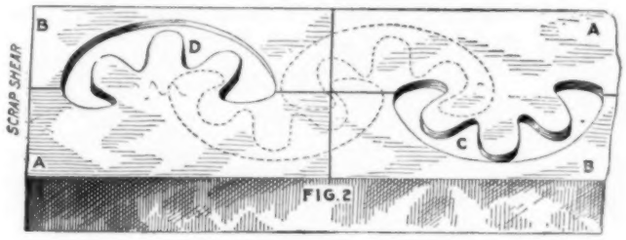


FIG. 2. THE DIE FOR THE NEW CLIP

should, so the speed of the presses was reduced, but as the noise was not lessened, nor the output increased, they were again put back to the original speed.

The feed is by hand, and at 160 strokes per minute the feeder keeps a steady pressure on the stock. Die breakage was caused usually by failure to feed the stock clear through to the stop, thus causing the punch to tilt.

The dies are about 4 in. wide, and the noise was somewhat abated by crowning the die about $\frac{1}{8}$ in. in the center; the punch face was of course kept flat, as the work must be flat. At the rear end and in front of the stop a scrap shear was provided. The short-sheared scrap falls into one receptacle and the clips into another. The clips are tumbled to remove all burrs and then blued.

Results of Tests on Torsion Springs

By Cleveland C. Soper

The torsion spring shown in Fig. 1 is used on a device I recently redesigned, and was tested with the results shown in Fig. 2 and Fig. 3. The function of this spring was to take a light load, it being used (two in parallel) in tandem with a heavy leaf spring in such

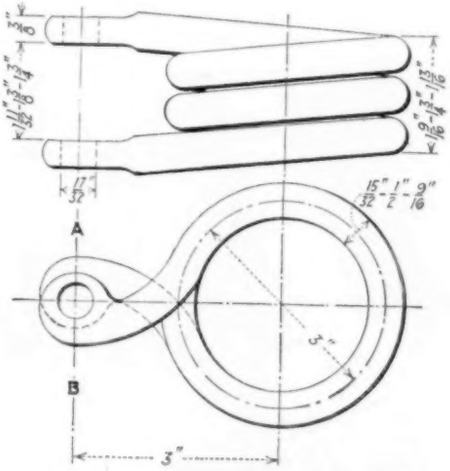
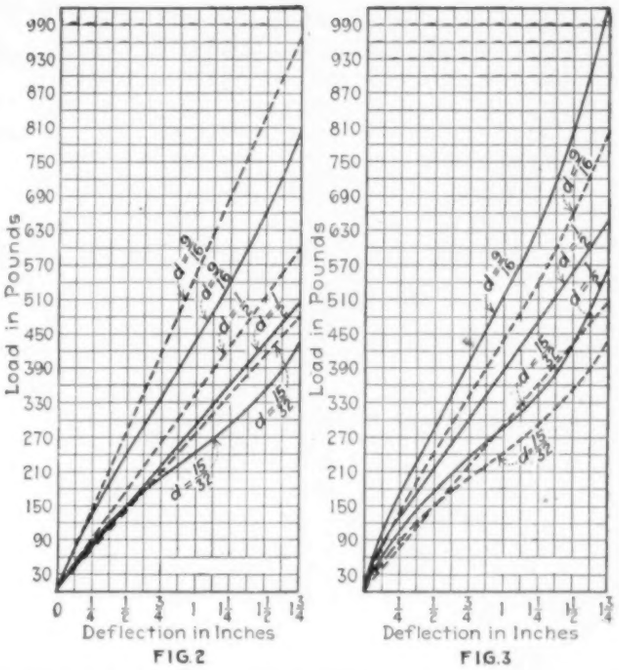


FIG. 1. AUXILIARY COIL SPRING

a manner that when the load became sufficient to compress the spring $1\frac{1}{2}$ in. on the axis *A-B* its guide brought up against a solid stop, thus throwing any additional load into the heavier spring.

The spring was used in three sizes, $\frac{15}{32}$, $\frac{1}{2}$ and $\frac{9}{16}$ in.,



FIGS. 2 AND 3. LOAD DEFLECTION DIAGRAMS COMPARED TO CALCULATED AND LOAD DEFLECTION, FREE COMPARED TO FIXED ENDS

and was made of tempered cast steel. Fig. 2 gives in full lines the load-deflection curves of the three springs (average of eight results) with the ends free to move on the fulcrum pins. In dotted lines are given the anticipated results, according to Prof. J. B. Peddle (*American Machinist*, June 19, 1913), where $a = \frac{3667\,M\,D\,N}{Ed^4}$ in which

M = Twisting moment, in. lb.
D = Mean diameter of coil, in.
N = Number of coils
E = Tension mod. of elasticity
d = Dia. of wire
a = The angle of twist, deg.

These results have been plotted for load on *A-B*, Fig. 1, on the assumption that the center of the spring moves up and down midway between the two spring fulcrums. The vertical force will then be the tangential force times $\cos \frac{a}{2}$ and the vertical distance = $6 \sin \frac{a}{2}$.

It is noteworthy in this set of curves to observe the difference between the calculated performance and the actual results. It is apparent from the difference being in the same direction in each case that the more flexible action is due to the projecting ends, which function somewhat in the capacity of an additional part of a coil. (My opinion is that the lower range of the $\frac{15}{32}$-in. spring is distorted due to an upsetting in flattening the ends.) This fact is brought out in Fig. 3, which has plotted in dotted lines the values shown in full lines in Fig. 2 (tested load with free ends) and in full lines the load with the ends fixed. The fixed end had a nut screwed down, securely binding the end in place. The additional load for a given deflection shows a shortening of the effective length of the spring by creating a point of contraflexure.

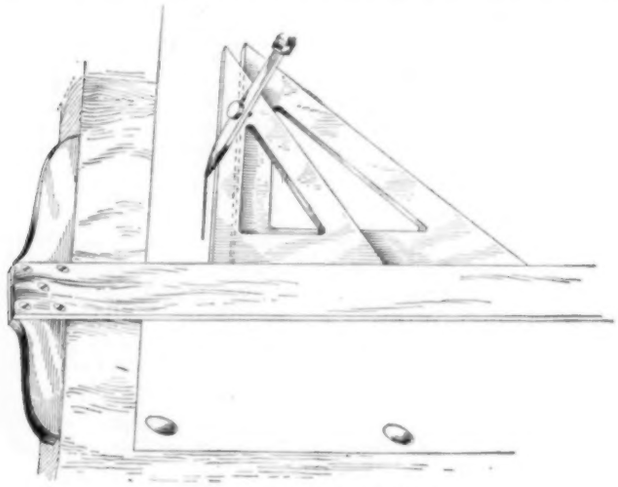
This feature was brought out first by failure in road

tests, and was objectionable from the standpoint of this particular design, as it caused this spring to take loads which were intended only for the larger one. This effect would not have been so pronounced in a larger number of coils. It is an interesting fact that so close to a straight line result can be obtained with three coils of this design.

Using Two Triangles to Avoid Blotting

By Wilfred Dickson

When making a tracing it is often necessary to make some very heavy lines, and in using the ruling pen along the edge of the triangle little pieces of lint or dust catch in the pen and the ink runs under the angle,



KINK FOR DRAFTSMEN

sometimes spoiling the tracing. To overcome this it is only necessary to use two triangles, one on top of the other as shown in sketch. You will find this to be a very handy way of finishing up lines that were left out, by sliding the upper triangle over the wet surface with no danger of blurring.

A Stringing Machine for Fence Barbs

By M. E. Duggan

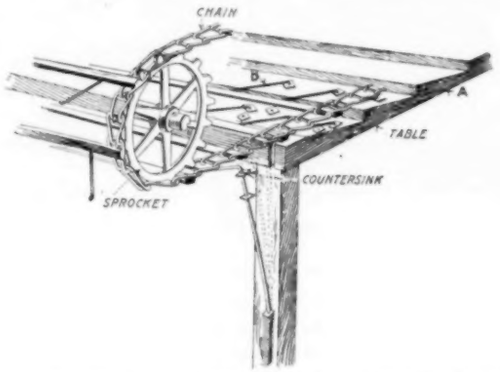
The barb used in the old-fashioned barbed-wire fence was a diamond-shaped steel punching having in its center a hole through which the wire was passed in the making of the barbed wire.

These steel barbs were gathered somewhat after the manner described in Mr. Hunter's article, page 1077, Vol. 49 of the *American Machinist*, excepting that instead of a four-pronged fork for gathering the barbs, a single wire was used for stringing as this operation was called.

Here are a few of the details of the machine construction. *A* is a table 6 ft. wide and 10 ft. long, the top face of which is corrugated and covered with sheet steel. It is elevated about 6 ft. from the floor and loosely fastened to a frame made of wood.

On this frame just above and flush with the sides of the table is mounted a pair of link belt chains, every third link of which is special, and to these links are fastened crossbars of wood. On each of the wooden bars are securely fastened 05 needles, as shown at *B*, and at the front of the machine are 50 wires (stringers) fastened at the lower end and free at the upper end, resting in V-grooves made in the front end of the table.

The table is made to oscillate by means of a mechanical contrivance at the back end of the machine. The steel barbs are scattered over the corrugated surface of the table and the "gathering" needles *B*, traveling in the direction indicated by the arrow, fall into the hole in the barbs and draw them to the end of the table



A GATHERING MACHINE FOR WIRE FENCE BARBS

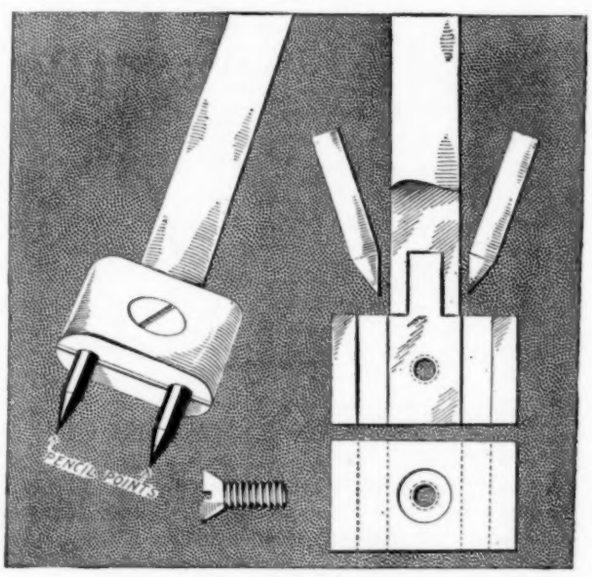
where the points of the needles are guided by grooves sunk in the steel plate, into the counter-sinks at the top of the string wires. With the points of the needles in the countersinks the pressure was sufficient to draw the stringing wires away from the table and thus allow the gathered barbs to fall until the wires were filled. The overflow barbs fell into a hopper at the front of the machine.

Two Pointed Ruling Pencil

By John H. Moore

A novel and useful drawing tool containing two pencil points in place of one is shown in the illustration.

The handle is made of ¼-in. cold-rolled steel, and the part containing the leads is of any size convenient to the user. The leads are held in position by tightening the small screw. This pencil is especially valuable in section lining of drawings or when ruling lines as guides for lettering purposes. There are many other uses to which it may be adapted.



TWO POINTED RULING PENCIL

ARMY ORDNANCE NEWS

Finding the Cost of Ordnance

BY LIEUT. L. S. GATTER

The wise manufacturer studies his "indirect expense" as closely as he does his direct labor. Cost methods should be applied to such matters as inspection, machine and equipment maintenance, etc., as well as to items of direct expense. This article illustrates and describes how the Ordnance Department watched its inspection costs.

IT is said that the cost of the war is to be borne by future generations. This will mean increased taxation for a period of years, which, coupled with the entry of the United States into strenuous competition for world trade, will make it necessary for our manufacturers to be more and more accurately advised as to the costs and efficiency of their organizations.

A committee of engineers recently defined an engineer to be, "one who economically directs man-power and by scientific design utilizes the forces and materials of nature for the profit of mankind." It is seen that the very essence of the definition involves an appreciation of relative values and costs, and so for those who have made efforts in the past to equip themselves with a cost system, it may not be amiss to outline the system which was finally adopted in the Ordnance Department of the United States Army for determining the costs of inspecting ordnance material.

To those who are maintaining a cost system, the following questions may be apropos:

(a) How much does it cost to obtain your costs?

(b) Do the results obtained lend themselves to a sufficiently quick analysis so that corrective measures may be adopted?

Methods for determining the answers to these and other questions are in some measure to be found by the following analysis, but more especially is this true for manufacturers who are facing problems relating to inspection.

THE TYPE OF SYSTEM FOR THIS WORK

The purpose of any inspection is to insure that the materials being produced meet certain requirements. The essential factors of successful inspection are that it is accurate, prompt and economical both in man-power and in money. Particularly during the government emergency the essential man power had to be conserved.

Inspection is inherently an incidental charge and for this reason the importance of economy in connection with it is often overlooked in view of the great sums necessary for a direct charge in actually producing the material. This fact, taken with the proposition that inefficiency and waste are said to be condoned by victory would seem to mitigate against the importance of establishing a careful analysis of the costs of inspection, but when it is considered that billions of dollars were involved in the production of ordnance material and that even a small percentage of this sum would still run into the millions, it immediately becomes apparent that a careful check was necessary. Moreover, it was felt that it would offer a method of comparison of the inspection systems installed in the various manufacturing plants producing ordnance material. A tentative selection having been made from various types of familiar cost-accounting methods, equipment was set up for a short trial period.

The entire costs in dollars and cents of carrying on the work of inspection was determined by adding the total wages and salaries in the Home Office together with the operating expenses of the Home Office, depreciating furniture and equipment according to commercial practice, and including the total of the traveling expenses necessary for supervisors, etc., who were stationed in the Home Office. This total overhead expense was distributed to the various plants manufacturing ordnance material on the basis of the relation which the total wages and salaries of inspection personnel at an individual plant bore to the total wages and salaries of inspection personnel at all the plants. By expense of inspection at the plants is meant the total wages and salaries at the plant together with the operating expenses and the travel occasioned by the personnel assigned to the plant going to and from the plant. The Home Office expense is occasioned by the field personnel, and therefore the wages and salaries of that personnel are a proper basis for distribution without including travel.

In connection with this question of the expense of travel, it is interesting to note that in the case of an inspector who was assigned to inspect material being manufactured at plants *A*, *B* and *C*, and to travel between those plants, it was impossible equitably to distribute this charge except by charging the expense of travel to the plant at destination. Wherever there were several contracts at one plant, the total plant expense including the pro-rated portion of the main office overhead was distributed to those several contracts on the basis of the cost of the direct labor spent on each contract to the total of the wages paid to direct labor on all the contracts. Indirect labor at the plant was also distributed in this manner. In other words, at the end of each semi-monthly period the total expenses of in-

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spection were distributed to all of the contracts involved, and having determined the number of contract units inspected and accepted for the government in the corresponding period of time by means of semi-monthly reports containing this information, it was possible to arrive at the cost of inspecting each contract unit in dollars and cents for that particular period. It was soon apparent that in view of the rapidity with which the volume of work increased that the necessary personnel to accomplish the system outlined above was prohibitive in cost, and would far offset any value which might attach to the determination of the results as expressed in the unit cost of inspection in dollars and cents for any contract unit. Moreover it was impossible to analyze the results obtained; that is, the unit costs in dollars and cents, for the reason that the various factors entering into the composition of a unit cost could not be segregated, and therefore, although wide fluctuations might occur, it was impossible to indicate the cause of them. The results proved to be very cumbersome and reports were of such a lengthy nature that they could not be properly analyzed, and so ramified as to prohibit active corrective measures. For these reasons it was apparent that the disadvantages of applying accounting methods to this problem would make it necessary either to give up an attempt to analyze the cost or else to introduce a system without these disadvantages.

N-333

PLANT Smith Jones & Co. LOCATION East Orange, N.J.

CONTRACT NO. C A 1003 COMPLETION DATE 4/19/19

CONTRACT FOR: 5,000,000 3" Cartridge Cases

U. S. TO FURNISH Brass Discs OPERATION Finish

REMARKS

FROM	TO	A UNITS ACCEPTED	B TOTAL HOURS DIRECT LABOR	C UNITS ACCEPTED PER HOUR PER MAN	D COST OF DIRECT LABOR PER HOUR	E COST DIRECT LABOR	F COST INDIRECT LABOR	G F/E	H NUMBER DIRECT EMPLOYED M	J F	REMARKS:
1/15/19	1/31	5,000	100	50	.40	40.00	10.00	25%	5	4	Hypothetical case

FIG. 1. OPERATION CARD USED IN DETERMINING INSPECTION COSTS

Agreement Reached After Careful Review of the Situation

After a careful review of the situation it was agreed that the purpose of any cost analysis of inspection must be to obtain data and set standards to aid in securing the speed and economy consistent with accuracy, also to permit comparisons between plants as well as to furnish a basis for predicting the necessary personnel for inspection on new contracts.

Another consideration affecting the type of system to be chosen for this work was that results should be obtained in time to make it possible to take corrective action where necessary. It was also felt that the reports and results obtained might be accomplished in a routine manner, but that the practical application of these results should by all means be left to trained personnel.

A system was established by which an analysis could be obtained of the amount of direct and indirect labor utilized and the results obtained with it. Certain definitions were essential; chief of these were the definitions of direct and indirect labor.

Direct labor was considered to be the labor of all operatives expended in *the actual examination for acceptance* of units or in the direct supervision thereof. Indirect labor was defined to be all executive, administrative, clerical or stenographic labor in the plants applied to inspection. In order to accomplish this analysis it was necessary to adopt a method which involved a consideration of three factors:

(a) The number of units on any operation, forging, machining, finishing, etc., which could be inspected and accepted by one inspector in one hour.

(b) The average cost of direct labor per hour for inspecting various operations.

(c) The percentage relation between the indirect and the direct labor.

These factors could readily be found without the use of additional personnel since certain people were always required in connection with the preparation of the payrolls and worked under peak load conditions in payroll periods. These individuals and between times were assigned necessary duties pertaining to the cost analysis.

Reporting the Progress of the Work

The inspectors in the various plants were required to make periodical reports as to the progress of the work, showing the number of contract units which had been accepted during that period. These reports were primarily for the use of other organizations but were placed at the disposal of the personnel operating the cost system. The time cards from the plants, upon which the inspection personnel at plants were paid, were also in their possession and the backs of these time cards were provided with space to indicate the exact number of hours spent on the inspection of material under the several contracts which might be in process

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at any particular plant. This determined the hours of direct labor spent on any operation at that plant. By referring to Fig. 1, it will be seen that this amount was entered in column B, the units accepted having been entered in column A. Care was observed that the contract numbers and operations described in the progress reports agreed with the contract numbers and operations indicated on the time cards. The number of units accepted in a given period appearing in column A, divided by the total number of hours of direct labor spent in accepting those units in that period appearing in column B gave the units accepted in one hour. From the time cards was obtained the average cost of direct labor per hour appearing in column D. If there were four employees at $4 per day and two at $2 per day and one enlisted man at approximately $2.50 per day, the average daily rate is $3.21 and the average cost per hour would be 40c. In column E appears the cost of direct labor which is obtained by multiplying the entry in column D or the cost of direct labor per hour, by the entry in column B, which is the total number of hours. In column F appears the cost of indirect labor which is taken directly from the time cards for clerks, stenographers, administratives and executives, or from pay vouchers in the case of officers. If there is more than one operation in process at the plant, the amount chargeable to each operation is determined by pro-rating the entire amount of indirect labor at the plant to each operation on the basis of the relation between the direct labor on that operation to the total amount of direct labor at the plant.

M-166 ANALYSIS OF COST OF INSPECTION 6"Howitzer Shell (Class VI Sec.3)

Operation	Unit Cost Of Inspection $	Estimated Unit Price $	%	Remarks
Steel	.0277 per U	$5.32 per U	.0052	
Forging	.07	2.75	.025	
Machining	.268	9.25	.029	No copper bands, base covers, caulking wire, fuze hole plugs
Loading	.146	8.00	.018	
Assembling	.040	2.00	.020	
Cart.Case	.029	4.25	.0068	9.93" long 271 cu.in.cap.wt.6.1] with primers
M.C.B.D. fuze	.027	2.67	.010	5,000 in a lot
110 gr. primer	.0053	.14	.0375	
Smokeless Pdr.	.004	1.88	.0212	Nitro cellulose base(7 perforated cyl.gr.) 3 zones 3 bgs.
T. N. T.	.00695	6.94	.001	13.87#
Copper Bands	.000272	.64	.0004	
Base Covers	.00244	.25	.0098	
Miscellaneous	.00240	.27	.0091	
(caulking wire, fuzehole, plugs & cart.cloth)	.6368	44.36	.0144	600 in 1 lot (120¢ each)

FIG. 2. ANALYSIS OF THE INSPECTION COST OF A 6-IN. HOWITZER SHELL

Relation Between Indirect Labor and Direct Labor

In column G appears the relation between the indirect labor and the direct labor obtained by dividing the entry in column F by the entry in column E. This should decrease as peak load production on that operation is approached, since the numerator of the fraction should remain almost constant with a marked increase in the denominator until peak load production is reached. In column H and J appears the number of male and female operatives respectively as a ready reference in making an analysis without reference to the original records.

These operation cards were filed alphabetically by plants and at semi-monthly intervals averages were taken of three factors mentioned above in order to erect a standard for comparative purposes and to make other analyses.

A formula used in determining the estimated unit cost of inspection was the cost of direct labor per hour appearing in column D divided by the units accepted per man-hour, appearing in column C, giving the unit cost for that operation on the basis of direct labor. Then having determined the total cost of inspection from all sources readily accessible from the disbursement books, and comparing the total cost with the cost of direct labor obtainable from the payrolls, a percentage relation was immediately obtained, which could be used for "loading" the estimated figure based on direct labor only. In other words, if the total cost of direct labor was 50% of the grand total cost, the estimated unit cost based on direct labor only would be "loaded" by 50% of itself in order to give the estimated unit cost based on the entire inspection expense and including all overhead charges. These latter estimated unit costs were subsequently compared with unit costs obtained by the original system of obtaining unit cost of inspection in dollars and cents previously described and no differences were obtainable up to the third decimal place.

Some Results Obtained with This System

As an example of the possibilities of predicting personnel requirements for future work, assume that work has been started on a contract for 500,000 three-inch cartridge cases to be completed in eight months. A theoretically perfect production schedule would enable this plant (assuming that it started work at a maximum capacity and was a plant which had had a previous contract for the same class of material) to complete 62,500 per month or 31,250 in each 15-day period. In other words there would be offered for inspection 31,250 completed units per period. If it was found by referring to the averages of column C that the standard for inspection of this material indicated that 15 of these units could be accepted in one man-hour, it is estimated that in a 15-day period of eight hours each including two Sundays and assuming the employees worked full time, or 104 hours, there would be accepted in one man-period 15×104 or 1560 units, but since there were to be offered 31,250 units, it is apparent that it will take 31,250 divided by 1560, or 20 men to do the work. If the units accepted per man-hour are below the average indicated by the standard

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or criterion for that operation, it indicates over-organization, unless for some reason the contractor was unable to offer for inspection during that period the customary number of completed units. (The work done by inspecting units subsequently rejected was found to be negligible but would, if sufficiently large, occasion this result.)

If the average hourly rate is in excess of the standard for that operation, it may indicate the use of unnecessarily expensive labor. One instance of this was found in the case of two steel mills in the same city where the average price of direct labor varied by 10c. an hour. Another case was discovered where the inspection force was composed of 100% male operatives when all other plants doing the same kind of work were using from 70% to 80% female operatives.

If there is an excessive relation between the indirect and direct labor it may indicate over-organization in the clerical force in a plant office. Instances were found where one inspection force for some reason could not measure up to the standard for units accepted per man-hour and the conditions which affect this are very numerous and varied. Considerable time and effort can be saved for example by depressing the pits in which inspectors stand in examining weighty material (since the material does not leave the floor level during the inspection). Raising this material to an inspection bench only three feet above the floor level would, in the case of a 9.2-in. howitzer shell, entail the expenditure of over 1,500,000 ft.-lb. of energy each day, providing 2000 shells were inspected during 24 hours.

After this system had been in operation for several months an expression of opinion was requested from the various executives who had made use of it from time to time. Sentiment was overwhelmingly in favor of continuing it, since it resulted in saving considerable sums and was of material benefit in gaging the efficiency of the plants and systematizing inspection work in them. It was found that the best application could be made in those cases where units were being manufactured at "quantity production" and that it was not applicable in cases where only one or two units were inspected during a semi-monthly period, as in the case of the railroad gun mounts.

Steel Inspection Results

Some of the most consistent results were obtained in the case of inspection of steel. Over a period of months the estimated unit cost of inspection was between 45 and 50c. per ton, and the cost of direct labor was between 50 and 51c. per hour. On the basis of approximately $80 a ton for steel, the percentage relation of the cost of inspection to the cost of material was about ½ of 1%. In Fig. 2 is given an illustration of the type of card compiled for ready reference, and in Fig. 3 is given an illustration of the material referred to in Fig. 2, both being self-explanatory.

The results obtained emphasize the importance of making *estimates* on a fundamentally sound basis rather than compiling elaborate cost statements by means of some typical accounting methods. These cost statements are apt to be submitted to executives who, by reason of their complexity, are not in a position to make advantageous use of them. The cost of such a system is very often excessive, whereas the cost of installing and operating the system outlined here was negligible in comparison to the total payrolls, and the results were speedily obtained, lent themselves to rapid analysis, and so made it possible to inaugurate corrective measures immediately.

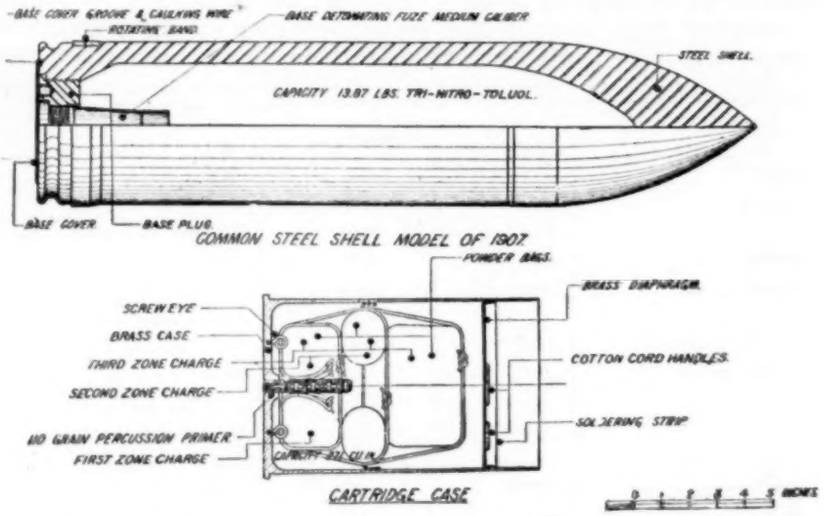

FIG. 3. COMMON STEEL 6-IN. HOWITZER SHELL REFERRED TO IN FIG. 2

Abstracts of Recent Office Orders of General Interest

No. 586, Mar. 13. Capt. Philip S. Charles is designated as alternate contracting officer for the Rochester District, with authority to approve vouchers.

No. 587, Mar. 14. Capt. C. A. Kanter is designated as alternate contracting officer for the Toronto Ordnance District, with authority to execute, in accordance with the determination of the Imperial Munitions Board and the assessors, settlement contracts on behalf of the United States, and other contracts incident to the termination of contracts and orders in Canada.

No. 588, Mar. 14. First Lieut. J. H. Little is designated as alternate contracting officer for the Chicago District Claims Board.

No. 592, Mar. 17. Maj. F. X. Colleton is designated contracting officer with authority to execute, where necessary, contracts incident to the sale or disposition of surplus material, equipment and property, in accordance with determinations of the Salvage Board, for the Boston District Ordnance Office, succeeding Lieut.-Col. Thomas F. Brown. Maj. Colleton has also been authorized to approve vouchers for this office.

No. 594, Mar. 19. Mr. Robert Kelly Prentice is designated as a member of the Philadelphia District Claims Board, appointment effective Mar. 14.

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No. 597, Mar. 19. Capt. G. L. Redman is designated contracting officer with authority to execute in accordance with the determination of the Bridgeport District Claims Board, settlement contracts incident to the suspension or termination of existing contracts and orders. He is also authorized to execute, where necessary, contracts incident to the sale or disposition of surplus material, equipment and property, in accordance with the determination of the Salvage Board.

No. 598, Mar. 21. Capt. Simon S. Martin is appointed Survey Officer for the Pittsburgh District Ordnance Office, and as such shall be attached to the staff of the Pittsburgh District Claims Board, appointment effective Mar. 8.

PERSONALS

Second Lieut. Perry S. Lewis, formerly sales manager for D. D. Aldrich Co., Vincennes, Ind., has been discharged.

* * *

Capt. C. Hedgcock, who is a mechanical engineer, has been discharged. He has been on duty continuously in Washington.

* * *

Second Lieut. Edward R. Fenn, who was commissioned in August, 1917, has left the service. He is a graduate of Yale and has served at Camp Upton and the Raritan Arsenal.

* * *

Second Lieut. Herbert Fiers has left the service. He is a graduate of Newark Institute of Technology and before being commissioned was employed by the Cadillac Motor Co., Detroit, Mich.

* * *

Capt. William H. Varley, a graduate of the Brooklyn Polytechnic Institute, has been discharged. He was formerly employed by the Chalmers Motor Co., Detroit, Mich., as motor service manager.

* * *

Capt. R. E. Blankenbuehler, who is a graduate of Washington and Jefferson, and was employed, before being commissioned, by the E. I. du Pont de Nemours & Co., has been discharged from the service.

* * *

First Lieut. Walter J. Devine, who entered the service as an enlisted man in May, 1917, has been discharged. He was formerly a student at Dartmouth College and was employed by the D. & H. Shoe Co., Harrisburg, Penn.

* * *

First Lieut. John F. Dryden has been discharged. He is a graduate of Yale and was formerly employed by the Prudential Insurance Co., Newark, N. J. His duties have been in connection with the priority of material for the department.

* * *

First Lieut. Charles P. Vauclain, who was a student at the University of Pennsylvania, and formerly employed by the Baldwin Locomotive Works, Philadelphia, Penn., has left the service. His home address is 2 Sagamore Road, Worcester, Mass.

Second Lieut. Edgar F. Heselbarth, who enlisted in January, 1918, has left the service. He has been on duty at Camps Cody and Green on supply work. Lieutenant Heselbarth was formerly a student at the University of Pittsburgh, and in civil life was a member of the firm of W. H. Heselbarth and Sons, Pittsburgh, Penn.

* * *

First Lieut. William M. Bowman, who has been on duty since he was commissioned, at Saltville, Va., under the control of the Nitrate Division, has been discharged. He was educated at Purdue University and was formerly employed by the Central Construction and Supply Co., 2222 Arch St., Philadelphia, Penn., as a refrigeration engineer.

* * *

Capt. Frederick D. Manning, who was employed by Cheney Bros., South Manchester Conn., as industrial engineer before he was commissioned first lieutenant in June, 1917, has been discharged. He is a textile engineer and a graduate of Lowell Textile School. Captain Manning has been on duty in the small-arms section, Production Division.

* * *

Second Lieut. Robert L. Giebel, who was commissioned in November, 1917, and served as production officer at the American Rolling Mill Plant and elsewhere in the Cincinnati Ordnance District, has been discharged. He is a mechanical engineer, a graduate of the University of Cincinnati, and was formerly with the Cincinnati Milling Machine Co.

* * *

Second Lieut. Marshall L. Fawcett has been discharged after 14 months' service. He is a graduate of the Ohio State University and was formerly employed by the Ohio State Civil Service Commission on organization work. His service has been with the civilian personnel section. He was stationed first at Washington and then at Toronto, Can.

* * *

First Lieut. John N. H. Christman, who was commissioned in May, 1917, has been discharged. He is a mechanical engineer, a graduate of the Case School, Cleveland, Ohio, and was formerly employed by the City of Cleveland, Ohio. Lieutenant Christman was for a long time in service with the Inspection Division and on duty at the Remington Arms Co., Ilion, N. Y.

* * *

Maj. Allen H. Clarke, who was commissioned in November, 1917, has been discharged. He has served as chief of the Cost Accounting Section since March, 1918. Prior to that time he was stationed at New York doing similar work. Before entering the service Major Clarke was a member of the firm of Clarke, Oaks, Trismen & Clarke, 68 William St., New York.

* * *

Capt. Dana M. Lasley has left the service. He was commissioned first lieutenant in August, 1917, and had previously been employed by the Domestic Engineering Co., Detroit, Mich. Captain Lasley is a graduate of the George Washington and Ohio State Universities. His service has been on engineering work in connection with motor equipment both in Washington and at the manufacturing plants through the Middle West.

Lending Versus Selling

FROM all parts of the country the friends of vocational education are inquiring about the fate of the Caldwell Bill which proposed to lend the government's surplus machine-tool equipment to educational institutions. This proposal was incorporated by the Senate Military Affairs Committee as an amendment to the Army Appropriation Bill. Our readers are aware, of course, that this bill as well as many others did not reach its final vote on account of the legislative jam in the last few days of the last session. It will come up when Congress again convenes.

In the meantime so many inquiries have been directed to the Secretary of War that the War Department has issued a special form letter which we reproduce herewith.

(The italics are ours.)

WAR DEPARTMENT
THE ADJUTANT GENERAL'S OFFICE
WASHINGTON

In reply
refer to March 17, 1919.

Dear Sir:

The Secretary of War directs me to acknowledge the receipt of your favor with reference to the lending of machine tools by the War Department to technical schools and universities (H.R. 15625.) Although no action on the matter was taken by the last Congress and the War Department has no authority to dispose of the tools along the lines proposed, this letter is sent to you to acquaint you with the attitude of the War Department. While there is every desire to assist these institutions, the department cannot, after a thorough study of the situation, approve the legislation in its present form. It is not believed that a loan of the tools can be acceptable either to the government or to the borrowers. ***There can be no certainty as to the length of time for which the borrowers may hold the tools, and any school or university would hesitate to make preparations in the way of expensive laboratories or shops to place the tools where they could not be sure of holding them.*** The distribution of tools in this manner would be exceedingly expensive to the government; first, in the organization necessary to lend the tools in an intelligent manner; second, the maintaining of an inspector service to protect the interests of the government inasmuch as the tools would still remain government property and the War Department would be responsible for them. Should Congress decide to act in the matter, it is believed that a much preferable solution of the problem would be to authorize the War Department to sell these articles at 10% of their cost value, the proceeds of the sale to go toward paying the expenses of the sale. In this manner the schools would receive absolute title to the tools and machines at a nominal price and the expense to the government would be practically limited to the value of the tools.

Very truly yours,
(Signed) P. C. Harris,
The Adjutant General
per J. C. A.

JEH

"There can be no certainty as to the length of time for which the borrowers may hold the tools." Why not?

Surely the efficacy of the proposed League of Nations deserves a better opinion on the part of its advocates than this! Is the next war so imminent as to make it unprofitable for a trade school or college to install machines borrowed from the government because

Machine Tools to Schools

of the likelihood of its being asked to relinquish these tools to a munition factory in the immediate future?

We hardly think so. This generation has had all the war that it wants. The same widespread, almost universal, horror of war which has been engendered by the last four years and which, more than any other factor, guarantees the success of a League of Nations to prevent war, will insure a satisfactory tenure of possession to educational institutions borrowing war tools. These are the evident probabilities.

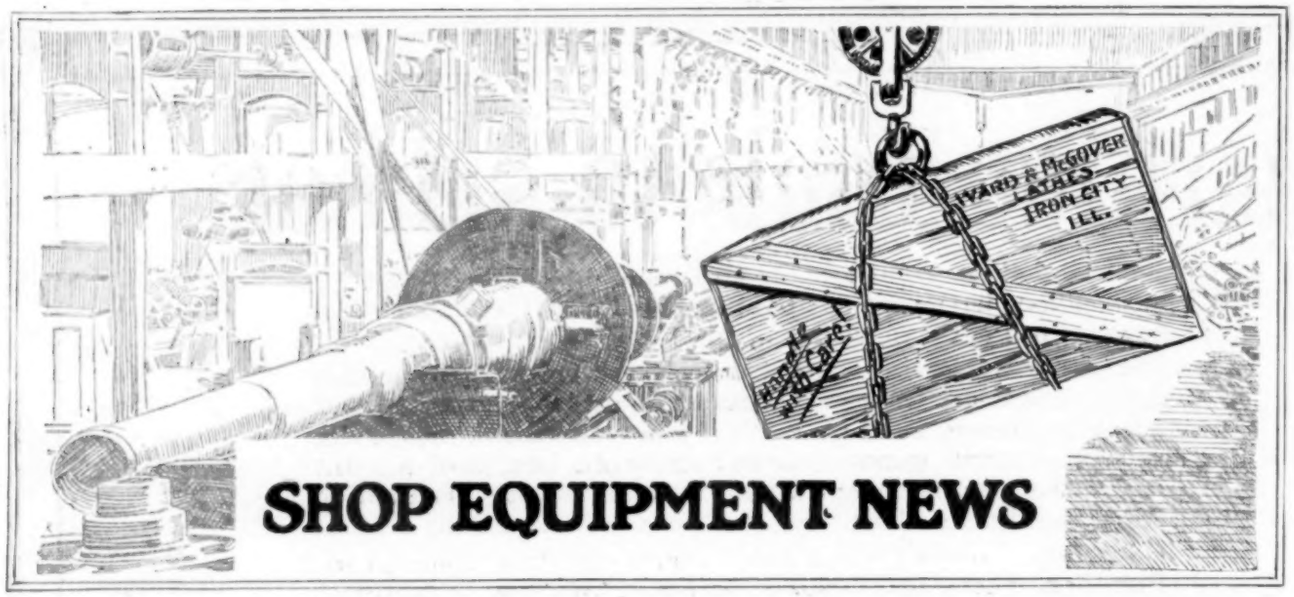
But if the above italicized contention of the War Department is correct, how much more necessary is it then for the government to retain the title in these tools?

The logic in the Adjutant General's letter strikes one as being on a par with that of Cole Hargis of Breathitt County. A neighbor asked him for the loan of his rifle to use on a squirrel hunting trip. "Ef I loan yo' all that gun I'm liable to spile yo' trip by comin' after it in a hurry any minute, 'cause I seen the Jackson brothers a hangin' aroun' town an' they're layin' for my scalp, so I guess it'll be better for yo' all to buy that gun."

Better for the neighbor perhaps but rather risky for Cole.

There are other objections to the War Department's suggestion of selling these tools instead of loaning them. A sale proposition at 10 or even 5% of the cost price of the tools would favor the wealthy institutions and discriminate against the poorer ones. The measure of capability of securing equipment would not be the need of the institution but the wealth of the institution. The country school which drew upon the limit of its purse to provide quarters and instructors for vocational training would be unable to raise the additional cash (however modest this sum might seem to a more fortunate city institution) wherewith to buy equipment. It is not a democratic plan. It is a plan to save the War Department the bother of using judgment and discrimination in distributing these tools and to save them the trouble of looking after them afterwards. There is no necessity for an elaborate organization to accomplish these purposes, providing business methods are used in handling them. The Ordnance Department at present lends rifles and all sorts of military equipment to state military organizations and military schools. There has been no uncertainty of tenure of possession of these war implements by the borrowers nor has there been any considerable amount of expense involved in keeping track of them.

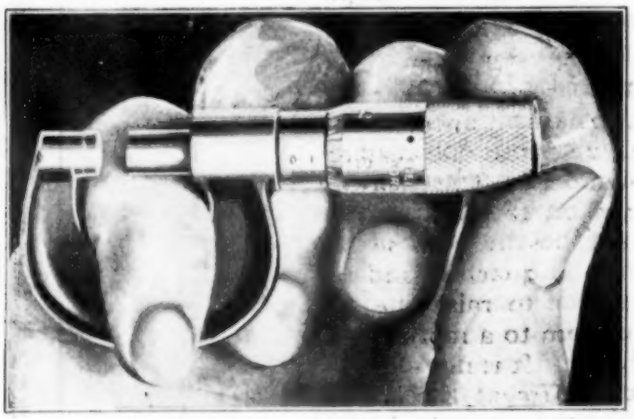
We believe that the proposal should go through in its original form. This will take care both of the probability of peace and the possibility of war, and after that possibility has been eliminated and the League of Nations becomes a demonstrated reality, these loans can readily be changed into gifts or sales.



SHOP EQUIPMENT NEWS

"Reed Junior" ½-In. Micrometer

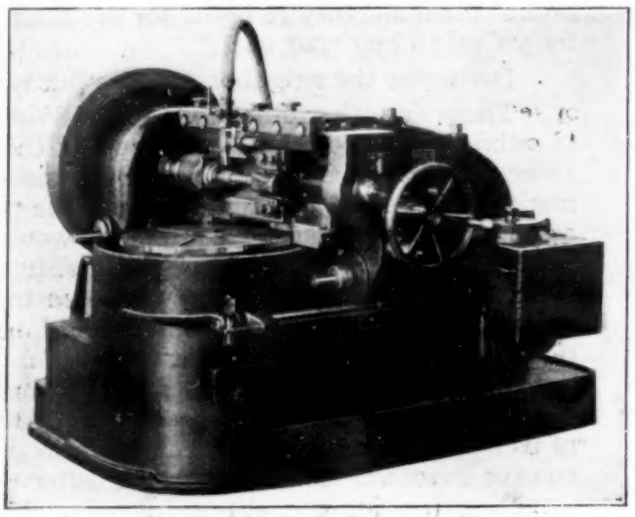
The Reed Small Tool Works, Worcester, Mass., has developed a new ½-in. micrometer caliper of sturdy construction known as the "Reed Junior." The barrel, spindle and thimble diameters are the same as those in the larger micrometers of the same series but the lengths have been reduced. It is equipped with a solid anvil and instantaneous two-part thimble adjustment. It is small enough to be slipped into the vest pocket but large enough to be operated by one hand. It is claimed that a firm grip can be obtained on the concave web of the frame even under oil. The finish is in dull nickel to reduce reflection and care has been taken to make the graduations easy to read. The micrometer will be finished with English or metric graduations and with a locknut and ratchet stop if these features are desired.



REED JUNIOR ½ IN. MICROMETER

Gould & Eberhardt 18-In. Worm-Wheel Generating Machine

Gould & Eberhardt, Newark, N. J., have just placed on the market the 18-in. wormwheel generating machine shown in the illustration, which has been brought out in answer to the demand for a machine for the manufacture of wormwheels for use in motor trucks, tractors, elevators, and other types of work where gear reduction is necessary. The machine is automatic in action and will generate wormwheels with a tapered hob, having a tangential feed; with a straight hob, the hob being fed into the wormwheel and not across it; and will also cut wormwheels with a fly tool.



GOULD & EBERHARDT 18-IN. WORMWHEEL GENERATING MACHINE

Maximum diameter of wormwheel cut, 18 in., from 10 to 100 teeth, including even and prime numbers also from 100 to 120 teeth in even numbers, with hobs having from single to quintuple thread inclusive; maximum diameter of hob, 5½ in.; maximum length of hob, 8 in.; tangential travel of cutter slide, 10 in.; maximum distance from center of cutter to center of work spindle, 13½ in.; minimum distance from center of cutter to center of work spindle, 3 in.; fixed distance from top of faceplate to center of cutter arbor, 7 in.; diameter of portable cutter arbor, 1¼ in.; countershaft speed, 800 r.p.m.; driving pulley, 16 x 4½ in.; weight, 8600 lb.

The latter application is said to be particularly desirable where experimental work is being carried on, and it would be an expensive proposition to make up a hob to cut one worm gear. The drive to the cutter spindle is through a worm and wormwheel, a large flywheel being mounted directly on the end of the cutter spindle. To insure rigidity the table is mounted in a permanent bearing in the base, while the cutter or hob carriage is mounted on a stanchion adjustable in

a horizontal direction. This construction permits the work table to be arranged with a long cylindrical hub bearing, in addition to a conical and flat bearing and an indexing wormwheel of large diameter which could not be incorporated if the work table were mounted in an adjustable carriage. Another feature is that the work table or faceplate is at a height that is convenient for unloading and loading. All running parts are accessible, and all necessary operating levers are conveniently located at the front of the machine, giving an operator full and instant control without changing the position. The machine is driven from a single pulley, a high-speed clutch being incorporated to provide for stopping and starting. This clutch is operated by a lever located at the front of the machine.

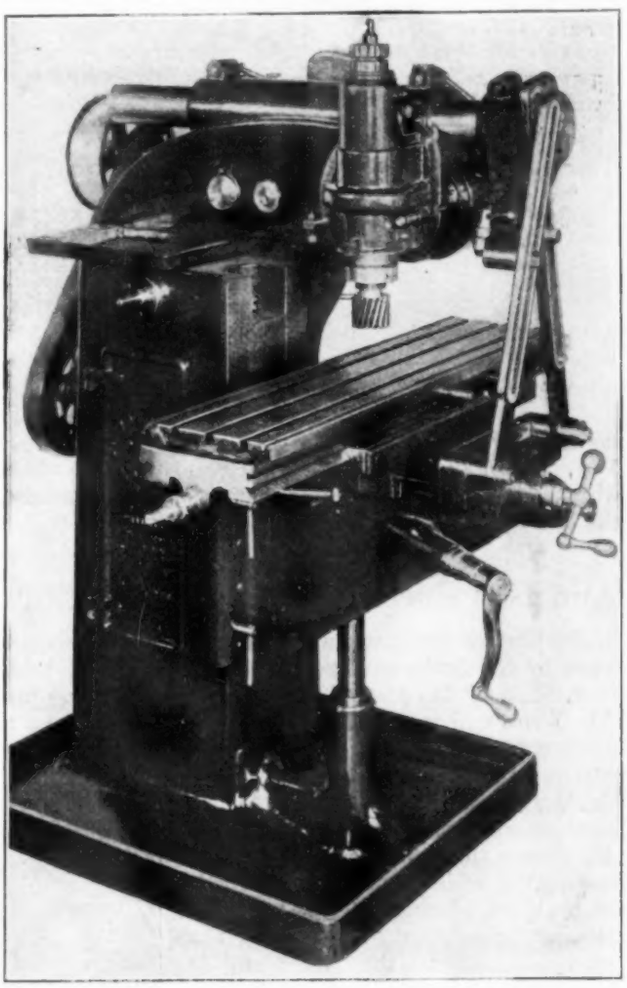
There are six speed changes for the cutter, ranging from 58 to 183 r.p.m., in order to allow hobs of various diameters to be run at the proper speed for the material being cut. To enable the operator to take a second cut through a wormwheel when using a tapered hob or fly tool without losing the lead, a differential mechanism is incorporated. This is also an advantage, as it permits changing the feed without changing the lead gears. When using a straight hob with automatic infeed, however, the differential is not required and a means is provided for locking it.

The cutter arbor is portable and the cutter carriage has automatic tangential feed, in one direction, and a power return. An automatic stop on which is located a graduated dial is incorporated and may be set to stop the cutter carriage at any predetermined point. The stanchion is equipped with automatic infeed and power return. When feeding automatically into the revolving wormwheel blank an automatic stop is used. The latter is also equipped with a graduated dial so that the operator can set it to stop the work at any predetermined point. When tangential feed is being used, the stanchion is adjusted to the proper depth of tooth and then securely bolted to the base of the machine. In adjusting the stanchion by hand, a dial graduated in thousandths and furnished with a vernier is used to set the hob and wormwheel blank at the required center distance.

The cooling compound is circulated by a centrifugal pump attached to one side of the machine and driven by gears. The pump may be disconnected by means of a clutch when the material is such that its use is not necessary.

Van Norman No. 20 "Duplex" Milling Machine

The Van Norman Machine Tool Co., Springfield, Mass., is bringing out a small "Duplex" milling machine to be known as No. 20. The ram is 30 in. long and can be moved in and out 11½ in. over the top of the column by means of a crank handle. Two lever binders are fitted to lock the ram in position. The cutter head is attached to the side of the ram and can be held in any position between the vertical and the horizontal. The spindle is 15¾ in. long with cone-type bearings and the front end has a No. 13 B. & S. taper hole. The gear mechanism runs in an oil bath inside the ram and gives 12 changes of spindle speeds from 21 to 350 r.p.m. The gear mechanism is driven through steel bevel gears by a splined shaft supported by a bracket at the side of the column and carrying a 10½-in. drive pulley. The latter runs at a constant speed of 385 r.p.m. A chain-driven gear box affords a range of 16 table feeds from ⅜ in. to 12 in. per minute. The table has a working surface 42 x 9¾ in. and a 28-in. automatic longitudinal feed. The saddle is 24½ in. long and has a 12-in. automatic traverse feed. The box-type knee can be moved vertically a distance of 18 in. by hand. Suitable harness with



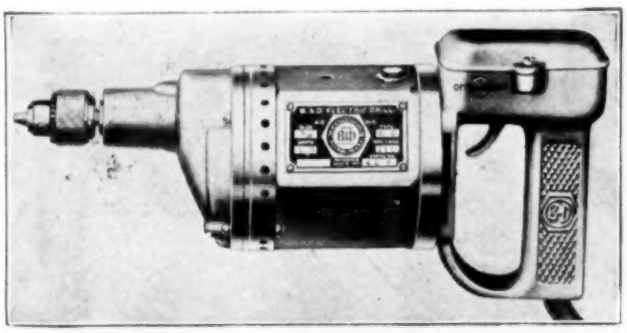
VAN NORMAN "DUPLEX" MILLING MACHINE

straps is provided to secure the solid-steel 4-in. overhanging arm to the knee to improve its rigidity under either vertical or horizontal cuts. With the machine are supplied a countershaft with 10 x 4-in. pulleys for forward and reverse drive at 335 r.p.m., a swivel vise with 7 x 1½-in. jaws opening 4½ in., a draw-in spindle for holding large taper-shank mill mounts or arbor, one ¾ in. split collet, one reducing collet with No. 7 B. & S. taper hole, one 2¾-in. end mill, one cutter arbor and a set of wrenches. If desired semi-universal or full-universal centers, a sub-head and a universal slotting attachment can be furnished separately.

Black & Decker Portable Electric Drills

The Black & Decker Manufacturing Co., 105-115 South Calvert St., Baltimore, Md., has recently placed on the market two new types of portable electric drills. These are 3/16- and ¼-in. sizes and are equipped with a pistol grip and trigger switch. Both models are one-hand drills. The current is controlled by pulling the trigger, without the necessity of changing the position of the

hand holding the machine. It is also claimed that drill breakage is less because the operator does not have to change the position of his hands to switch off the current. Both models have ⅛-hp. motors with series compensated windings, and operate on any current from direct to 60-cycle alternating. Cooling is accomplished by means of a vane impeller mounted on the armature shaft which causes a forced circulation of air through



BLACK & DECKER ⅛- AND ¼-IN. ELECTRIC DRILLS

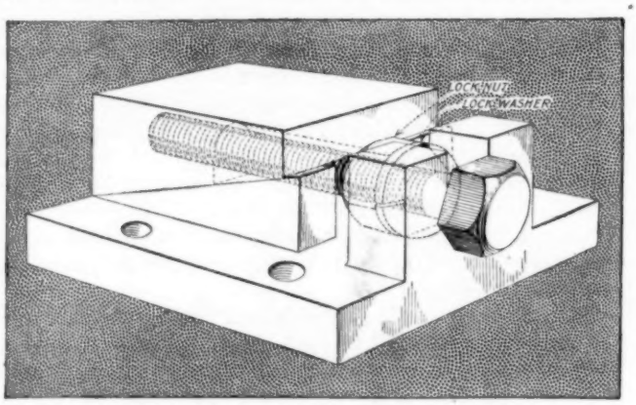
the housing. Gears run in a grease-tight compartment. The speed of the $\frac{3}{16}$-in. drill is 1600 r.p.m. with no load, while that of the ¼-in. drill is 1200 r.p.m. with no load, the energy consumed in both cases being 175 watts.

Anderson Pneumatic Scraping Machine

The illustration shows a pneumatic scraping machine made by the Anderson Bros. Manufacturing Co., Rockford, Ill., as it is operated in a shop. It is claimed that this device will enable one operator to do three times as much work as he could do by the old hand method and without tiring him nearly as much. Various forms of mounting are supplied to suit the needs of the user. As shown the ram is pivoted on a small truck which runs back and forth on the 4-in. I-beam which is mounted at any convenient height on the column. When the machine is operated, the truck is locked on the forward stroke, but is released on the return stroke, and is then free to be moved along the beam as desired. The scraping tool is held in a similar position to a hand tool and operated in the same manner, freedom of motion being insured by the universal joint connecting the ram to the truck. The rod which carries the scraping tool is mounted on ball bearings so that the tool can work at any angle and on either side. The ram requires about 8 cu.ft. of free air at 80 to 90 lb. pressure to operate it, and its forward speed is controlled by an oil governor. The length of stroke is determined by the operator as he moves the sensitive valve control with his right hand, the length of stroke varying with the opening of the valve. When the valve is released, the ram returns the tool to its original position ready for the next working stroke. For smaller work a turntable with T-slots for clamping the work is provided. It has a tilting top mounted on a universal joint, and the whole upper section rotates on ball bearings. The tilting and rotation are controlled by a foot pedal mounted at the side of the base.

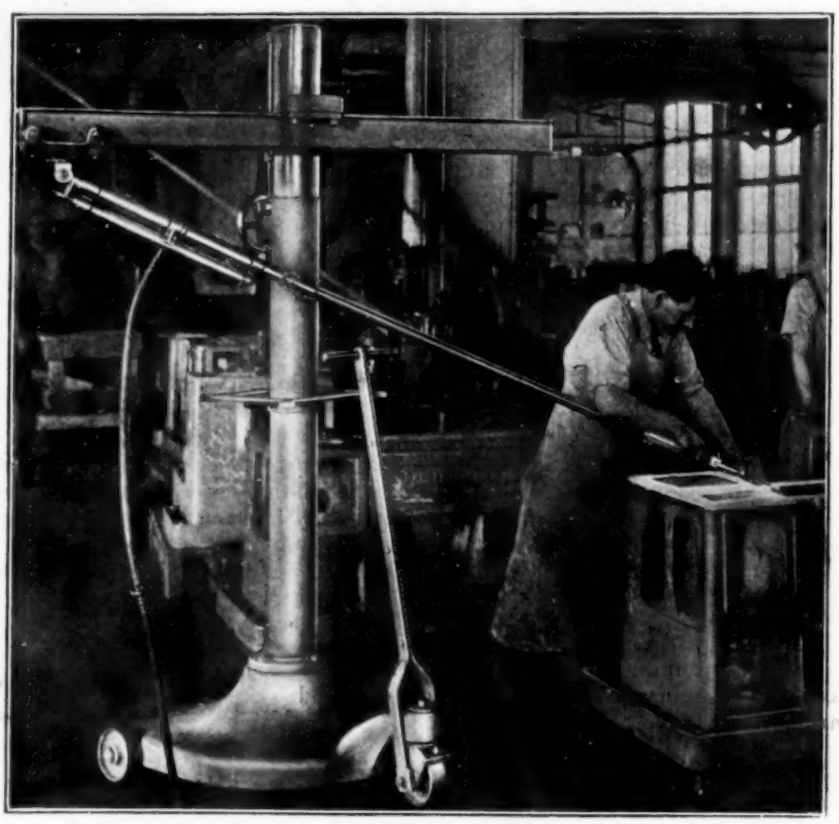
Cincinnati Planing-Machine Leveling Blocks

To overcome the difficulties encountered in trying to keep a planing machine leveled up on the old style leveling blocks, the Cincinnati Planer Co., Cincinnati, Ohio, has brought out the block shown in the accompanying illustration. It consists of a baseplate and



A PLANING-MACHINE LEVELING BLOCK

a sliding member operated by a drawbolt having a fine thread and fitted with a locknut and lockwasher. The baseplate is cast with an extra wide flange and is drilled with four 1-in. holes. Its inclined surface is

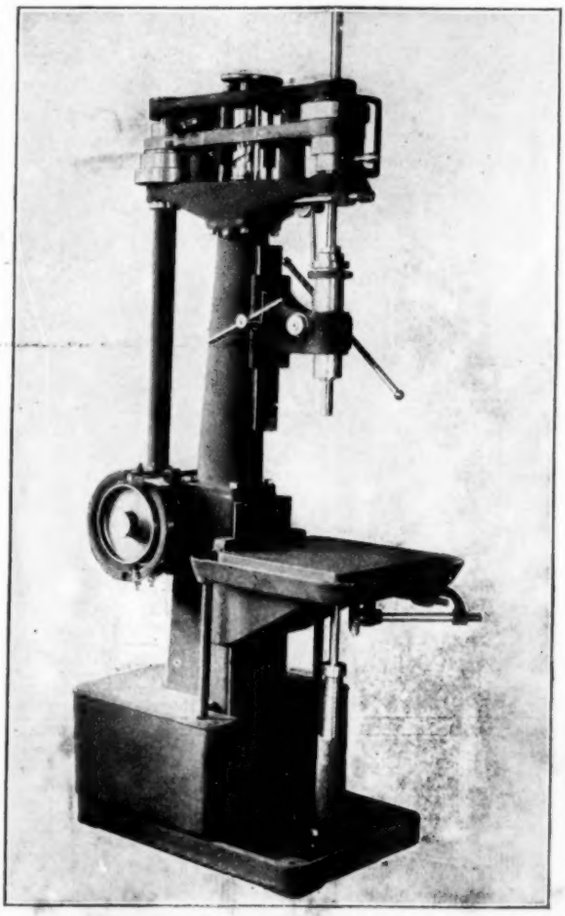


PNEUMATIC SCRAPING MACHINE

ground as is also the bearing surface of the leveling block which is tapped for the drawbolt and so designed that 2½ in. of thread are always engaged. The drawbolt is ⅞ in. in diameter and is threaded practically its entire length. The locking arrangements are intended to hold the adjustment against any changes due to vibration.

Pierle Sensitive Drilling Machine

The illustration shows the high-speed, ball-bearing sensitive drilling machine recently put on the market by the Printing Machinery Co., Cincinnati, Ohio. High-duty, double-row ball bearings are mounted in the various members in what is claimed to be a dustproof and grease-tight manner. Four spindle speed changes are obtainable by means of the combination plate and face cam, belt-shifting device carried on the top bracket.

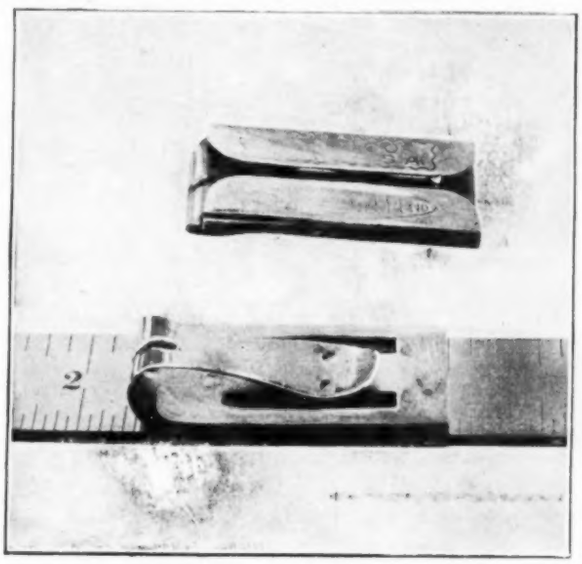


PIERLE DRILLING MACHINE

The shift is so arranged that the belt is shifted off the step on one cone before it starts onto the step on the other cone, thus permitting a tight belt to be used. The tension is increased by a spring-actuated, ball-bearing idler pulley which is released from contact before the belt is shifted. The cones are finished inside and out to improve the balance and are mounted on steel sleeves running in ball bearings. The steel spindle sleeve has an inserted wide-face rack operated by a hardened-steel pinion and carries a thrust and two radial bearings in which the spindle runs. In the gear box mounted on the rear of the base are hardened, chrome-nickel-steel spiral gears running in oil. The drive shaft running from the gear box to the top bracket is inclosed in a tubular casing which helps to stiffen the machine and also guards the revolving shaft. The machine is being built with single or multiple spindles, with and without pump-power feed, and with two types of motor drive.

"Tamco" Pocket Scale and Square Holder

The "Tamco" pocket scale and square holder manufactured by the Automatic Machine and Tool Co., Inc., 87 Frankfort St., New York, is shown in the illustration. It is made for machinists, toolmakers and other mechanics who use pocket scales and squares, and serves two purposes. As a holder for either of these tools, it can be clipped to the pocket, apron or overalls, keeping the tool in a convenient place and reducing the chances of loss. When the tool is to be used, it can be clipped outside the pocket and when it is no longer required the clip can be reversed and the tool secured inside the pocket. In addition, the holder can be used as a scale reader as it slides freely and has a straight edge. It is made in one piece from nickel-plated spring steel, has no sharp corners to do damage and no small parts to be lost or broken or to get out of order.



"TAMCO" POCKET SCALE HOLDER

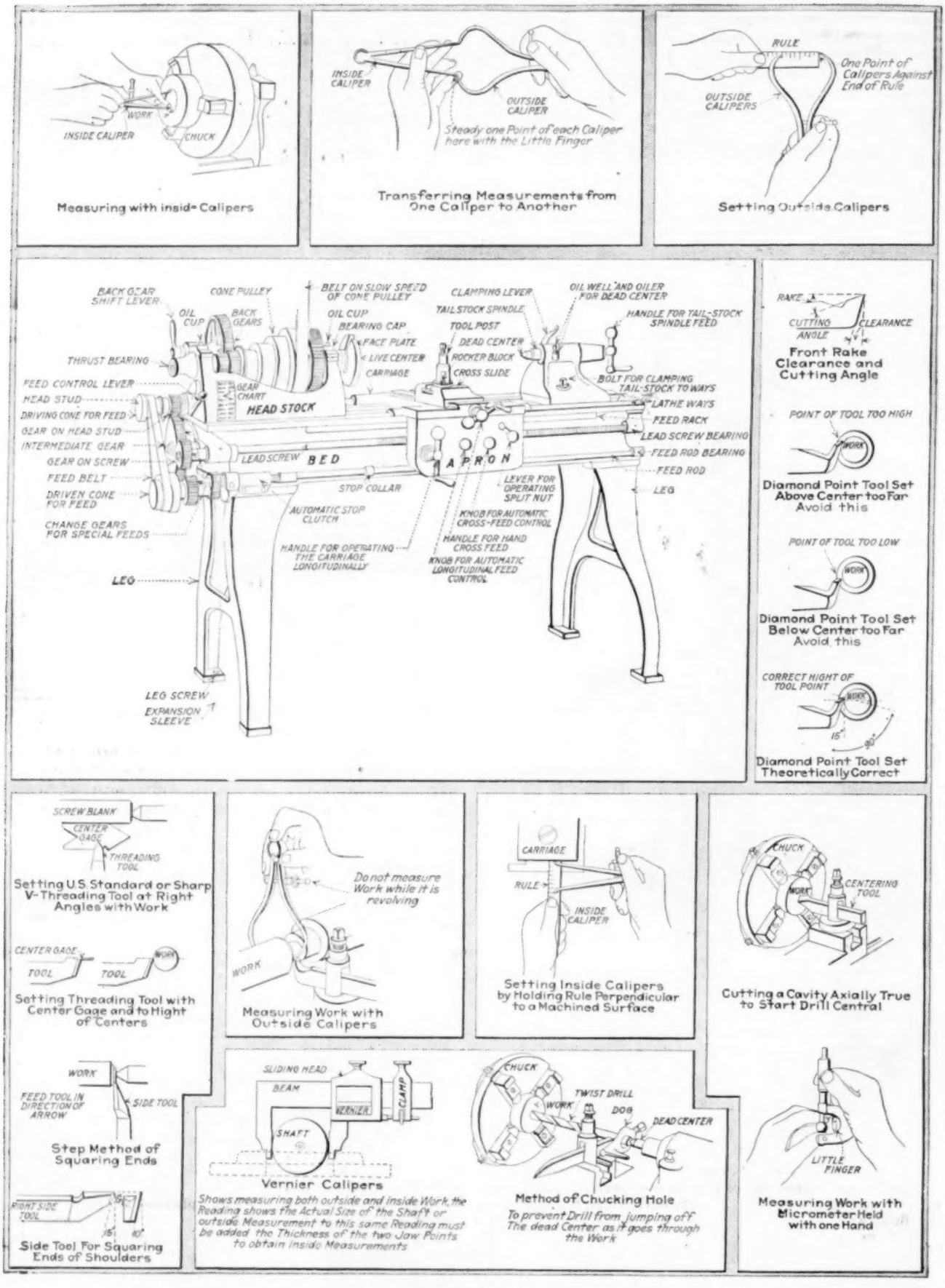
Students' Chart

By R. H. Kreider

The illustration on the next page shows a chart which was designed for the assistance and convenience of the students in a trade school. This and similar charts are mounted on a board and attached to the machine which it represents.

The central figure shows the machine (a lathe in this case) with the names of the parts, and the surrounding figures show details of various rudimentary operations. The charts can be made for any of the standard machine tools, such as milling, grinding and planing machines, etc.

This method of imparting information need not be confined to schools alone, but would be quite helpful in regular machine shops, especially now when handy men and laborers are doing machinists' work.

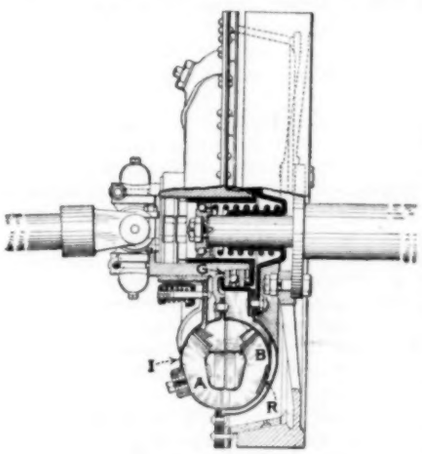


INSTRUCTION CHART

LATEST DEVELOPMENTS IN THE AUTOMOTIVE INDUSTRIES

Aircraft • Motor Trucks • Tractors

A promising form of liquid-operated automatic transmission called the Radcliffe turbine drive has been placed on the market by the Automatic Transmission Co., New York. This transmission is a combination of a centrifugal pump and a hydraulic turbine, and it consists of two moving parts, a driven member or runner *R* and a driving member or impeller *I*. The driving member is a pressed-steel housing carrying the impeller of a centrifugal pump and is fastened to the motor shaft. The driven member is a turbine runner located in the driving member



and rotated absolutely independent of the driving member. These two members are not connected, their only contact being at the bearings, both running submerged in oil. A double-acting thrust bearing *G* is provided to take any thrust produced on the driven member, but mainly serves to take the pull exerted in disconnecting the drive from frictional engagement with the flywheel of the motor. The spring and thrust bearing in the center of hub are of standard construction and serve to hold the drive in engagement with the flywheel and also to permit it being disconnected to enable the gear-shifting lever to be operated if desired. This is, however, seldom necessary. The action of the transmission is as follows: The two members *I* and *R*, which are constructed exactly alike, are so placed that the oil leaving the impeller blades *A* impinges upon the blades *B* of the runner *R*. These blades absorb the greater part of the velocity energy, and the fluid with its residual velocity energy flows toward the center of the runner *R* and back into the eye of impeller *I*, thus completing a closed circuit for the impelling fluid. The flow of the fluid at low engine speeds is so gentle that no rotation is imparted to the driven member *R*, the oil simply circulating through the runner back into the impeller *I*. By increasing the speed of the motor an increased torque is obtained until with wide open throttle the full torque of the motor will be transmitted to the rear wheels of the car at a standstill or at whatever speed they may be turning. This gives a very smooth but rapid acceleration, without shock or jar of any description, and a flexibility of drive and ease of operation. It is also said to be possible to so proportion the passages as to make a reduction gear of any desired ration which is practically positive in action.

At present the main interest of the aircraft industry is concentrated around the efforts of the United States and England to cross the Atlantic Ocean by airplane or dirigible. Both competitors in this contest possess machines the past performances of which bear out the possibility of fulfilling the prediction that there are machines in existence today that are capable of making a transatlantic flight. Without discussing the abilities of the different types of machines, an analysis of the nature of such a flight will show that the enterprise includes questions of navigation which are not as yet satisfactorily answered.

A transatlantic air voyage may be fairly called a blind flight, as it is flying in fog, clouds and darkness when the direction of the machine depends solely on navigating instruments. When an airplane is flying straight its course laterally and directionally may be determined quite accurately from the compass, the banking indicator and lateral clinometer. The compass will not, however, indicate accurately and instantly when the airplane is turning and is not dependable for a short interval after straight flight is resumed. If an airplane is banked steeply and turning rapidly, the banking indicator merely shows whether or not it has the proper bank for the turn it is making.

It is therefore evident that to solve these problems of navigation the airplane has to be provided with an instrument which would accurately and instantly indicate any change from a straight course or from the horizontal. The developing of a perfect instrument of this kind is naturally closely bound up with the establishing of an air route between America and Europe and would be one of the biggest factors in solving the future aerial transportation problems.

Plans have been worked out by the Kerr Steamship Co. to operate a fleet of airplanes to deliver mail to ships 24 to 36 hours after they leave port. The mail, in waterproof bags, will be dropped on deck by the pilot.

The Texas Airplane Manufacturing Co., capitalized at $1,000,000, has recently organized in Dallas, Tex., for the purpose of constructing and operating an airplane manufacturing plant. The chief promoter of this project is Lieut C. C. Taylor of Lexington, Ky.

The Federal Board of Vocational Training expressed the opinion that the extensive use of motor trucks, tractors, lighting and power systems on farms will create a demand for skilled mechanics, to operate and repair all farm machinery operated by gasoline

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The Rogers Una-Drive Motor Truck Corporation was recently incorporated at Sunnyvale, Calif., for the manufacture of a new type of four-wheel drive truck. The main feature of the design is the simple type of drive employed on the front axle. It is similar to the rear full-floating type, having a toggle to allow for steering, inclosed inside a ball cast integral with the housing. The steering is accomplished through a socket fitting over the ball and held in place by two steering pins.

In the course of his remarks on "The Case for the Airship" at the aeronautic meeting of the Society of Automotive Engineers on Mar. 7, Ladislas d'Orcy announced that he had private advices to the effect that an English concern had under construction four Zeppelin-type dirigible airships for trans-Atlantic passenger and mail service. These craft are to be 800 ft. long with a maximum diameter of 100 ft. and will be equipped with engines that will develop a total hp. of 3500. Their endurance will be 80 hours with full load and it is expected that they will make the eastern trip between America and the British Isles in 50 hours and the western trip in 60 hours. They will have accommodations for 140 passengers and their baggage and will be manned by a crew of 19. It is planned to charge $225 for passage and six cents an ounce for mails. At first the airships are to be regularly operated during the months from May to October only, but all the year service is merely a question of time and improvements. There are to be two sailings weekly from each side.

Sparks from the

British Machine Tool Situation

Demand Continues Good in Most Lines But Considerable Uncertainty Still Exists

There is a somewhat peculiar condition in the Sheffield district due to the inactivity in openhearth-steel departments. This comes from the lack of orders to replace the war-time activity for shell steel. The crucible-steel branch is also quiet on account of the slackened demand for turning tools for shells and other munitions.

On the other hand there is a large demand for wire rods, especially of the cheaper grades, to be used in reinforced concrete. The production of tools and finished steel goods is being pushed and the supply does not as yet anywhere near keep pace with the demand. Boilers and electrical machinery seem likely to continue to be busy.

Machine-tool makers in the Yorkshire district report good-sized orders, but labor conditions are not settled and they are unable to judge of the future with certainty. In the Sowerby Bridge district there is a demand for a large variety of machine tools and similar machinery and excellent prospects are reported. F. Berry & Sons are building heavy triple-geared 40-in. swing lathes with beds up to 30 ft. in length. There is also considerable plate handling machinery for ships and boilers going through.

In some districts there seems to be something of an oversupply of lathes, while on the other hand some makers have a fair amount of lathe business booked. This is particularly true of H. Broadbent, Ltd., while Summerskill Bros., continue to be busy on planing machines up to 60 in. Some of these are of the two-belt type while others are motor-driven.

The Scottish labor situation is reported to be more settled and work is on the whole proceeding steadily on the 47-hour week basis. There is some increase in unemployment, but not enough to be alarming and it is expected that this will very shortly decrease. The British Industries Fair will be held in Kelvin Hall, Glasgow, from Sept. 8 to 19. It is also expected that there will be a motor exposition at the same place in January, 1920, and that an engineering and shipbuilding exhibition will follow next spring.

The demand for shipping seems to continue and some of the large shipbuilding firms report plenty of orders on their books. Concrete vessels with electrically-welded reinforcing steel are being talked of more favorably, and standard ships are being turned out along the Clyde. One company, Barclay, Curle & Co., Ltd., built during the war 45 vessels of various types for the Admiralty, ships for the French Navy and merchant tonnage to the number of 57. They also repaired 3,243 vessels and delivered 400 airplanes and seaplanes. They are one of the oldest concerns on the Clyde, having just completed their hundredth year in business. Forgings and both iron and steel castings are in demand, and boilermakers and general engineers are managing to keep busy.

Machine-tool builders in the Johnstone district report orders enough to keep them busy. This includes lathes, planing machines, hydraulic and motor-driven presses and general woodworking machinery, as well as plate machinery for the shipyards.

There seems to be an increase in the tendency to use jigs and fixtures in manufacturing, and this is reflected in the manufacture of special small precision horizontal milling machines by Hunt & Sons of the Manchester district. These machines are designed particularly for jig and fixture work, the table swivelling on trunnions for angular work. There is also a demand for fluting machines for twist drills up to 2 in. in diameter indicating an extension in the manufacturing facilities for these tools.

There is still some question as to the continuance of women in the machine shops and this is likely to be heard from later. Those employed on strictly war work are practically out of the shops at the present time. The success of the various training schools during the war will probably lead to the utilization of more apprentices or unskilled labor unless there is some arrangement made to the contrary.

One notable case in which the management should be congratulated is that of the National Gas Engine Co., Ltd. This shop has been able to turn over from war to peace work without the necessity of discharging a single old employee and, at the same time, they have reinstated all their demobilized men. The Manchester municipal tramways are preparing to build 100 new cars which will help take up the labor slack in this district.

London, Mar. 27, 1919.

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Aeronautic Convention Starts May 1

The second Pan-American aeronautic convention and exhibition will be held at Atlantic City, N. J., on May 1 and will last until June 1. The convention will be under the auspices of the Aero Club of America, the Aerial League of America and the Pan-American Aeronautic Federation. A program outlining each day's activities has been issued.

Foreign Trade Committee Organized

It is officially announced that a committee on foreign trade, composed of members of virtually all government departments and boards, has been formed to stimulate and coördinate American trade abroad.

The foreign trade committee has been organized under an authorization signed by President Wilson. All government offices dealing in any way with foreign trade questions are represented. Among the urgent questions to be treated immediately are tonnage allocation, marine freights, cable and radio facilities, reconstruction loans, Latin-American loans, labor and immigration, key industries, such as dye making, strategic raw materials and a unified organization for buying in Europe.

The committee will act as a clearing house for government departments involved in foreign trade questions, it was explained. Business men will deal with the same agencies of the government as heretofore and the committee will be concerned only with subjects that relate, in a general way, to foreign trade policy and development of American interests abroad. Its functions will be advisory to the government executives actually dealing with specific trade affairs.

The committee held a preliminary meeting last week and a sub-committee on organization was formed.

It is understood that the persons actually sitting in conference will vary from time to time, but the departments represented include: State, Commerce, Treasury, Agriculture, Labor, War, Navy and Shipping Board, War Trade Board, Federal Trade Commission, Tariff Commission, Railroad Administration, Interstate Commerce Commission and Post-Office Department.

* * *

New Fuel for Motors

Development too late for use in war time of a motor fuel which adds 10 miles an hour to the speed of airplanes, and has possibilities for use in automobile racing has been announced by the Bureau of Mines. The liquid, a combination of benzol and cyclohaxane called hector, costs about $1 a gallon. While of military value, it is not regarded as practical for commercial purposes.

Another combination developed by the bureau, consisting of benzol and gasoline, has been found to be more powerful than gasoline alone, and is expected to prove of value in industry. The comparative scarcity of benzol makes its production to supplant gasoline on a large scale improbable at present.

World's Industrial Forge

By E.C.Porter, News Editor

General Meeting of Engineers of New York

An engineers' symposium was held at the Engineering Societies Building in New York on Mar. 26 for the purpose of discussing "The Engineer as a Citizen." Gano Dunn, fellow and past president of the A. I. E. E. presided and formal addresses were delivered by Philip N. Moore on "The Civic Responsibility of the Engineer," Calvert Townley on "The Relation of the Engineer to Legislation," Nelson P. Lewis on "The Relation of the Engineer to Administration," Spencer Miller on "The Relation of the Engineer to Public Opinion," and Comfort A. Adams, recently appointed dean of the Harvard Engineering School, on "The Relations of the Engineer to Production and Distribution."

The meeting was held under the auspices of the Mining, Mechanical and Automotive Engineers and the members of the other societies were invited to attend. At the conclusion of the program, the meeting was opened to discussion and a resolution adopted directing the appointment of a committee to take steps toward the formation of an organization to include all the local engineering societies with the idea of closer coöperation and consequently increased power. Similar organizations of other cities were described and pleas were made for the formation of one national organization of engineers to bear somewhat the same relation to the many existing national societies as does the national government to that of the states.

* * *

Exhibit of Personnel Work

Employers and others interested in personnel work have an opportunity to examine the methods developed by the Committee on Classification of Personnel in the army at an exhibit being shown on the third floor of the Engineering Societies Building, 29 West Thirty-ninth St., New York. The exhibit, which began on Apr. 1 and will continue until Apr. 12, consists of a collection of wall charts, forms, photographs and models showing how the army finds out what men can do best and how it uses that information; how soldiers are trade tested, and how officers are rated and fitted into place; how the work is checked and supervised, and its results in the war.

The collection is being shown under the auspices of the National Association of Corporation Schools and the United Engineering Society, representing the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. It was on exhibition for several weeks at Washington, where it excited so much interest that in response to many requests the Adjutant General consented to its display in other cities. Two commissioned officers accompany the exhibit to explain its various features.

* * *

To Establish Permanent Exhibit of War Materials

The engineering and standardization branch of the Purchase, Storage and Traffic Division of the army will establish and maintain an exhibit of standard war equipment and supplies. The exhibit will contain samples of all varieties of standard articles necessary for war. It is especially intended for the information of manufacturers, and in order to have available at all times approved samples or specifications of samples needed to facilitate production. A list of the articles to be exhibited will be made public later.

* * *

Engineers' Club of Philadelphia Will Hold Informal Meeting

The Engineers' Club of Philadelphia will hold an informal meeting Apr. 9 at which Roland L. Cummins, of the Packard Motor Car Co., will give a demonstration of the Liberty motor. The method of manufacturing Liberty motors will be illustrated by motion pictures. The regular monthly meeting will be held Apr. 15 and will be addressed by S. M. Swaab on "Main Interchange Station Under the City Hall, Philadelphia Subway System"; the address will deal with unique construction methods made necessary by conditions imposing exceptional difficulties. A special meeting will be held Apr. 23 at which Arthur J. Baldwin, vice-president of the McGraw Hill Co., Inc., will present an illustrated paper entitled "The Devastated Area and Its Reconstruction." Mr. Baldwin was a member of a party of technical and business paper editors and publishers who were invited by the British Ministry of Information, as its guests, to visit Europe.

* * *

Argentine-American Chamber of Commerce Formed

Formation of an Argentine-American Chamber of Commerce in New York City, under the auspices of the Chamber of Commerce of Buenos Aires, has been announced by Enrique Gil, secretary of the organization. Its purpose is to foster trade relations between the two countries, to encourage investment of American money in Argentina, and to serve as a clearing house for all business. The membership will include citizens of both countries.

Aircraft Surplus Material Being Sold

Materials Disposal Section Has Been Formed and Machinery Will Be Sold at Appraised Price

There has been formed a Material Disposal Section of the Bureau of Aircraft Production, organized on a basis similar to that followed by large commercial houses which handle sales through branch offices. This section will be under the direction of First Lieut. Charles S. Shotwell. Sales will be made under the supervision of a sales manager stationed at Washington.

The Bureau of Aircraft Production will probably have for sale the following classes of material, and as soon as this material has been established as surplus and a policy for the sale of the same determined, the bureau will issue bulletins covering the material for sale.

Machine tools and fixtures.
Electrical machinery.
Dies, tools, jigs and gages.
Chemicals, paints and oils.
Metals.
Motor accessories.
Lumber.
Hardware.
Buildings and lands.
Fabrics.
Scrap.
Shop equipment.
Office equipment.
Miscellaneous.

Sales negotiations will be handled by salesmen in each of eight district branches, to be located in Boston Buffalo, Chicago, Dayton, Detroit, New York, Pittsburgh, and San Francisco. These salesmen will be authorized to make sales of property wherever located, after the same has been cleared by the Board of Sales Review of the office of the Director of Sales, so that the prospective buyers will communicate with the branch office in the city located nearest them.

This arrangement, it is expected, will make it possible for manufacturers needing machinery and supplies to purchase conveniently and at fair prices. The salesmen will have full authority to sell at the best offer made, provided that offer is at or above an appraised value arrived at independently, or at market value in the case of raw material.

* * *

Ships Now Owned by the U. S. Government

The United States Government now owns 555 ocean-going steel cargo ships aggregating 3,385,475 deadweight tons. In addition it has under contract 1,336 similar vessels of 9,275,006 deadweight tons. If our present program be car-

ried out, there will be under the American flag next year 16,732,700 deadweight tons of ocean-going steel cargo and passenger ships. This fleet will be the equivalent of almost half the merchant tonnage which plies the seas today under the flags of all nations combined. The government will own about 70 per cent. of it.

Business Items

The Gorham Tool Co., Detroit, Mich., is placing on the market a complete line of standard milling cutters and reamers which are designed for salvaging several times.

The Walcott Lathe Co., the Jackson Shaper Co., and the Jackson Machine Tool Co., of Jackson, Mich., have opened joint display and salesrooms at 254 E. Jefferson Ave., Detroit, Mich.

The Bettcher Manufacturing Co. of Cleveland, Ohio, manufacturer of steel stampings has opened a Chicago office at 30-32 N. Clinton St., with A. C. Dunn as its representative.

The Bridgeford Machine Tool Works, Rochester, N. Y., have opened branch offices at 50 Church St., New York, with F. C. Severin in charge, and also at 549 Washington Boulevard, Chicago, in charge of A. W. Van Buren.

The Colonial Tool Co., 33 Woodward Ave., Detroit, Mich., has been formed by R. H. Anderson and Otto Lundell for the exclusive manufacture of broaches. Their interests in the Michigan Tool Co. are still retained.

Baxter D. Whitney & Son, Winchendon, Mass., has been incorporated recently as Baxter D. Whitney & Son, Inc., with a capital stock of $1,250,000. The officers are: W. M. Whitney, president; Marcus L. Foster, treasurer; and Frank C. Smith, Jr., secretary.

The British branch of the International Oxygen Co., known as the Integral Oxygen Co., Ltd., has commenced the manufacture of I. O. C.'s electrolytic cells and other products for the British market. E. L. Byrns is the general manager in charge, with offices at 38 Victoria St., Westminster, London, S. W.

Wheelock, Lovejoy & Co., Inc., 1800 Columbus Road, Cleveland, Ohio, is building an addition to its warehouse, which will nearly double the present storage capacity. In addition to Hy-Ten special machinery steel, it will now carry in stock a complete line of Whelco carbon and high-speed steels as well as globe drill rods.

The Baldwin Engineering Sales Co., Baltimore, Md., has recently established its office, representing as manufacturers' agent, the Reliance Steel Co., Pittsburgh, Penn., and the National Forge and Tool Co., Erie, Penn. The territory of the new company includes the states of Maryland, Delaware, Virginia, District of Columbia, and part of Pennsylvania.

The Raybestos Co., Bridgeport, Conn., has placed on the market a new type of molded facing for multiple disc clutches. This new facing presents an unusual amount of frictional surface to the steel disc, providing it with more capacity than usual for a given size of clutch. It is composed of pure asbestos with a suitable binder, molded under tremendous pressure.

The New Britain Machine Co., New Britain, Conn., at its annual meeting of stockholders held recently, elected the following directors: F. G. Platt, H. H. Pease, R. S. Brown, A. Buol, H. E. Erwin, C. R. Hare, S. P. Goss, A. J. Sloper, M. C. Swift, J. E. Cooper, C. J. Parker. Subsequently the directors elected the following officers: President, F. G. Platt; vice president, M. C. Swift; treasurer, H. H. Pease; secretary, R. S. Brown; assistant treasurer, A. Buol; assistant secretary, H. E. Erwin.

Louis Besse, 39 Rue de Lappe, Paris, has opened an office at 120 Liberty St., New York. This is in charge of Mr. Arva Stroud who has recently returned from France where he spent over three years in machine-tool lines. During the past year Mr. Stroud was connected with the Machine-Tool Section, both as a civilian and as a commissioned officer, directing the purchasing of machine tools for the general purchasing agent of the American Expeditionary Forces. Being thoroughly familiar with conditions in both France and Belgium, Mr. Stroud is interested in furthering the sale of machine tools in those countries and can be of considerable assistance to any who desire to trade with either of these countries.

The American Hardware Corporation, New Britain, Conn., held its annual meeting of stockholders recently, and the following directors were elected: C. H. Baldwin, Philip Corbin, James S. Elton, Charles Glover, Benjamin A. Hawley, George T. Kimball, Henry H. Peck, Charles B. Parson, A. J. Sloper, C. F. Smith, H. W. Whittemore, Henry C. M. Thomson and Rollin S. Woodruff. The directors, at a subsequent meeting, elected the following officers: President, Henry C. M. Thomson; first vice president, Charles Glover; vice president, Benjamin A. Hawley; vice president, Carlisle H. Baldwin; vice president, Charles B. Parsons; treasurer, Isaac D. Russell; assistant treasurer, G. Ernest Root; secretary, G. T. Kimball.

Obituary

CHARLES F. BACHMANN, master mechanic of the Essex County Division, Public Service Railway, N. J., died recently after a brief illness from pneumonia at his home, 402 Williams St., East Orange, N. J. He was 33 years old and a mechanical engineering graduate of Cornell University. He had been employed by the Public Service Railway for 11 years.

Personals

J. E. MCCAULEY has been made vice president and general manager of the Birdsboro Steel Foundry and Machine Co., Birdsboro, Penn.

F. J. SCHWARB, formerly of Beals & Co. and the Cygnet Manufacturing Co., is now associated with the Aborn Steel Co. at Buffalo, N. Y.

ALBERT A. SCHEUCH of the sales department of the Epping-Carpenter Pump Co., Pittsburgh, Penn., has been made assistant sales manager.

NATHAN LESTER, who has had long experience in the die-casting industry has been made superintendent of the Acme Die-Casting Corporation, Brooklyn, N. Y.

GEO. K. ATKINSON, formerly superintendent of the Cincinnati Planer Co., is now eastern manager of the Manufacturers' Equipment Co., with offices in New York.

C. H. BREAKER has been made assistant sales manager of the Diamond Chain and Manufacturing Co., Indianapolis, Ind., in charge of their sales promotion.

F. R. CONROY, for many years connected with Strong, Carlisle & Hammond Co., has been appointed Cleveland manager for the Cadillac Tool Co., Detroit, Mich.

GIFFORD K. SIMONDS, general manager of the Simonds Manufacturing Co., Fitchburgh, Mass., has been added to the board of directors of the First National Bank of Boston.

CHARLES B. GILBERT, recently discharged from the navy, has taken a position as purchasing agent with the Babcock Printing Press Manufacturing Co., New London, Conn.

WALTER WILSON of the American Machinery Syndicate, 35 West 39th St., New York, has sailed for Spain to investigate the industrial machinery and mining apparatus lines.

F. W. SEBELIN, formerly master mechanic of plant No. 2 of the National Malleable Castings Co., has been made plant engineer of the Ferro Machine and Foundry Co., Cleveland, Ohio.

PAUL D. GOODMAN, formerly of the McClary, Jemison Machinery Co., of Birmingham, Ala., has been added to the sales personnel of the Epping-Carpenter Pump Co., Pittsburgh, Penn.

LEON E. THOMAS, vice president and general manager of the Birdsboro Steel Foundry and Machine Co., Birdsboro, Penn., has been elected president of the Reading Iron Co., Reading, Penn.

A. E. CARLE, formerly with the Baush Machine Tool Co., and Manning, Maxwell & Moore, has joined the Cadillac Tool Co., Detroit, Mich. as sales engineer in the machine-tool department.

C. E. LONG, has joined the engineering force of the Hart-Parr Co., Charles City, Iowa. Mr. Long has been for the past seven years with the Curtiss

Aeroplane Corporation, Hammondsport, N. Y.

W. H. DIEFENDORF, Syracuse, N. Y., has resigned his position as chief engineer and as a director of the New Process Gear Corporation, and is now with the Weeks-Hoffman Co., also of Syracuse.

EDMUND C. MAYO, who has held the office of general manager of the Worcester Pressed Steel Co., for the last five years, has resigned and accepted a similar position with the American Tube and Stamping Co., Bridgeport, Conn.

F. R. STILL, vice president and secretary of the American Blower Co., has left on an extended trip through Japan, China, Australia, and most of the European countries where he will investigate trade conditions in connection with export work.

E. F. CARLSON of Brooklyn, N. Y., has joined the engineering department of the Hart-Parr Co. During the war he was with the Subchaser Division with headquarters near the Brooklyn Navy Yard. Mr. Carlson was formerly with the Hart-Parr Co.

WILLARD B. JACKSON, who for a number of years has been Boston district manager for Wm. Jessop & Sons, is now associated with the Simonds Manufacturing Co., Lockport, N. Y. He has opened a New England office for them at 120 Milk St., Boston, Mass.

FRED H. WALDRON, formerly Minneapolis representative of the Chicago Pneumatic Tool Co., has been appointed manager of the pneumatic tool sales division suceeding J. G. Osgood, resigned. Mr. Waldron's offices are now at the company's headquarters in the Fisher Building, Chicago, Ill.

CHARLES W. UNBEHAUN, formerly of New York, and general eastern salesman for the Bailey-Drake Co., Chicago, Ill., has joined the Black & Decker organization as branch manager. Mr. Unbehaun will cover eastern New York and the state of Connecticut with the Black & Decker line of portable electric drills and accessories.

LEON BARD has resigned his position of assistant superintendent of the Naval Factory, League Island Navy Yard, Philadelphia, Penn., and has formed a partnership with E. Bowker under the name of Bard & Bowker, 967 North Warnock St., Philadelphia, Penn. They are conducting an authorized Ford service station in connection with their machine shop.

ERNEST T. GREGORY, formerly representative of the American International Corporation and manager of the International Banking Corporation, Pekin, China, has been elected vice president of the First National Corporation of Boston. Mr. Gregory at one time was connected with Lee-Higginson & Co. and later was a partner in the firm of Hambleton & Co., Baltimore, Md.

CLINE B. FINNELL has recently been appointed private secretary to Walter A. Zelnicker, president of the Walter A. Zelnicker Supply Co., St. Louis, Mo. Mr. Finnell, who has just returned from the Officers' Training School at Camp Pike, Arkansas, was formerly traveling secretary to the general superintendent of the C. B. & Q. R.R., and later private secretary to Clarence H. Howard, president of the Commonwealth Steel Co.

CAPT. GEORGE SYKES, R. A. F., A. M. I. E. E., who has been in this country nearly four years, attached to the British War Mission in a commercial capacity, sails for Europe in May. He has joined Messrs. Dutilh-Smith McMillan Co., as London manager of their engineering and railroad departments. For many years prior to the war, Captain Sykes was connected with electrical manufacturers and power and traction corporations in the sales and engineering departments. Captain Sykes will be interested in hearing from firms wishing to introduce the following products in Europe: Electrical and mechanical specialties for use in power and traction corporations, mining, aeronautical, steel, automobile, electrical, machine-tool, shipbuilding and cement industries and electric railway equipment. His New York address is 50 Broad St., and his London office is the Central Buildings, Totehill St., Westminister.

Export Opportunities

The Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, D. C., has inquiries for the agencies of machinery and machine tools. Any information desired regarding these opportunities can be secured from the above address by referring to the number following each item.

An agency is desired by a man in France for the sale of small tools. Correspondence should be in French. Reference. No. 28824.

A manufacturer in Italy desires to purchase iron, steel, brass, copper, aluminum, and lumber used in the construction of railway cars, and also machinery for making household utensils and hardware. Correspondence should be in Italian. Reference. No. 28776.

A member of a firm in New Zealand is in this country and desires to secure an agency from manufacturers only, for the sale of dairy machinery and supplies (including parchment and cheese bandage), can-making machinery, electrical supplies, electrical steel-tool blanks, copper wire (plain and coated), woven wire fencing, steel wire, wire nails, galvanized sheets (plain and corrugated), tin plate, tin steel, machine tools, woodworking machinery, sawmills and supplies, light-six motor cars, tires, trucks, road-building machinery, and engineering supplies. References. No. 28749.

A firm in Switzerland desires to purchase immediately and to secure an agency for the sale of machine tools, agricultural implements, and tools of all kinds. No. 28750.

Ing. A. Stauble, Foro Bonaparte 76, Milano, Italy, is desirous of extending the range of his electric and mechanical machinery business and would like to hear from American firms who desire to establish an agency for their products in Italy. He states that he is interested in electric appliances, fittings and materials, machines, tools, technical articles and instruments for the use of public work, dock yards, naval arsenals, etc., and in supplying mills and factories of all kinds.

Catalogs Wanted

The Artillery Ammunition Metal Components Division, Ordnance Dept., U. S. A., 7th & B St., E-7-208, Washington, D. C., desires duplicate files of catalogs from all machine-tool manufacturers who have made machines used in the manufacture of artillery ammunition. It is particularly desired to obtain drawings and general specifications of these special tools that have been manufactured and which do not appear in the general catalog.

Trade Catalogs

Bulletin No. 260. Walter A. Zelnicker Supply Co., St. Louis, Mo., Circular. Pp. 4, 3½ x 8½ in. A price list of steel sheet piling, any make, weight or length, also, of all kinds and sizes of pipe.

Broaching Equipment, Machines and Tools. The J. N. La Pointe Co., New London, Conn. Catalog, Pp. 56; 8½ x 11 in., illustrating and describing the various types of broaching machines and tools.

Pneumatic Tools. The Independent Pneumatic Tool Co., Chicago, Ill. Circular No. 30. Four-page pamphlet descriptive of the Thor line of pneumatic tools. Illustrations and specifications are given.

Tite Flex All-Metal Flexible Tubing. Titeflex Metal Hose Corporation, Newark, N. J. Bulletin, No. 102. Pp. 20, 4¾ x 7 in. This bulletin tells how Tite Flex is made, giving the various forms, sizes and prices.

Twist Drills, Reamers, and Special Tools. The Buckeye Twist Drill Co., Alliance, Ohio. Catalog No. 6. Pp. 60; 5 x 7½ in. A complete illustrated price guide of the line of reamers, drills and special tools put out by this company.

Automobile Jacks for Passenger and Commercial Cars. Republic Auto Parts Co., Long Island City, N. Y. Catalog, Pp. 24; 7 x 10 in., describing the line of Sterling jacks which are made in 14 styles. Many useful auto accessories are also illustrated and described.

Gasoline and Oil Handling Outfits. Gilbert & Barker Manufacturing Co., Springfield, Mass. Catalog 8-B. Pp. 28; 6 x 9 in. This is a catalog of the Gilbert & Barker equipment for handling gasoline and oil. Various sizes and styles of pumps and tanks are illustrated and described.

The Quigley Powdered Fuel System. Quigley Furnace Specialties Co., 26 Cortlandt St., New York. Bulletin No. 11. This is a 16-page booklet describing the equipment employed in the Quigley system for preparing, distributing and burning powdered fuel which is in successful operation on a variety of furnaces.

Landis Pipe Threading Machinery. Landis Machine Co., Inc., Waynesboro, Penn. Catalog No. 25. Pp. 48; 6 x 9 in. This catalog illustrates and describes in detail Landis stationary pipe die heads, pipe threading and cutting machines, rotary pipe and nipple threading die heads, pipe nipple threading machines and the Landis chaser grinder.

Markets for Electrical Goods in China and Japan. A report by Trade Commissioner R. A. Lundquist, published by the Bureau of Foreign and Domestic Commerce, giving a full description of the conditions governing the sale of electrical goods in China and Japan. Copies can be obtained for a nominal sum from the Superintendent of Documents, Washington, D. C.

Twist Drills, Reamers, Wrenches, and Drop Forgings. No. 91. The Whitman & Barnes Mfg. Co., Akron, Ohio. Catalog No. 91. Pp. 184; 5½ x 7½ in. A catalog covering the complete list of products manufactured by this company in the machinists' supply line, carbon and high speed twist drills and reamers, screw and drop forged wrenches, spring cotters and keys. Illustrations and prices are given.

Checking Thermocouple Pyrometers. Bulletin No. 867-B. The Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Penn. Catalog, Pp. 24; 7¾ x 10½ in. It discusses the importance of maintaining standards and of checking in pyrometry, and points out sources of error and the remedies for troubles in therocouples, millivoltmeters,

cold junctions and standardized thermocouples. This bulletin is distributed free of charge upon application to the above company.

Newton Slotting Machines. Catalog 49-A. Newton Machine Tool Works, Inc., Philadelphia, Penn. Pp. 28, 6 x 9 in. This catalog contains the latest information on slotting and upright generating planing machines. In the insert pages are shown photographs of cold-sawed, cutting-off machines, locomotive link grinding machines and horizontal milling machines, vertical milling machines, rotary planing machines, key-seat milling machines, and duplex locomotive rod boring machines.

Safety Grinding Wheels. Safety Emery Wheel Co., Springfield, Ohio. Catalog 9. Pp. 138; 6 x 9 in. Published to give information relative to the making of grinding wheels as well as to list special wheels used on various grinding machines. Descriptions of materials and processes of making are given, together with a description of the safety collar and directions for its use. There are suggestions for operating grinding wheels with tables for determining surface speed of wheels, decimal equivalents, etc. Following this are descriptions, specifications and prices of special wheels for different types of grinding machines. The catalog is fully illustrated and a complete index is given.

N. G. E. A. Data Sheets. National Gas Engine Association, Lakemont, N. Y. Bulletin. Pp. 82; 5⅛ x 8¼ in. Divided into three volumes, as follows: Vol. I, N. G. E. A. Standards and General Engineering Data; Vol. II, Pumps; Vol. III, Electrical Outfits. Vol. I gives useful information on gas engines and carbureter fittings, tables of standards and equivalents and data of general engineering; Vol. II is devoted to pumps, and it gives tables on atmospheric pressure, friction of pipes and elbows, stroke of piston speed, water equivalents, etc.; Vol. III contains data on battery sizes, generator sizes, wire sizes and lamps and gives a comparative table of resistances.

Structural Steel For Ships. Carnegie Steel Co., Pittsburgh, Penn. 2nd Edition, with additional tables and commentary. Pp. 60, 5 x 7¾ in. This pamphlet is of great value to the ship builder because it is the latest work on the subject of structural steel for ships and contains a great store of information and working data. The booklet gives tables on structural shapes recommended for ships and also includes facsimiles of standard order forms for shapes, plates and bars. The commentary describes and illustrates the kinds of rolling mills utilized in the manufacture of ship steel traces, the route followed by an order from a shipyard, through district and general offices to the mills, through the mills, to the shipping beds and thence back to the shipyard. It also recommends a convenient and uniform marking system for cargo vessel materials and a practical method of plain material storage at the yards—all fully illustrated by diagrams and figures.

New Publications

Gasoline and Kerosene Carburetors: Their Construction, Installation and Adjustment.—By Victor W. Page. Two hundred and thirteen 5 x 7¼-in. pages; 89 illustrations; bound in dark-green cloth boards. Published by the Norman W. Henley Publishing Co., 2 West 45th St., New York. Price, $1.50.

This is a simple, comprehensive treatise for practical men explaining the basic principles pertaining to carburetion, showing how liquid fuels are vaporized and turned into gas for operating various types of internal-combustion engines intended to operate on vapors of gasoline, kerosene, benzol and alcohol. The leading types of carburetors are described in detail, special attention being given to the forms devised to use the cheaper fuels such as kerosene. Carburetion troubles, fuel-system troubles, carburetor repairs and installation, electric primers and economizers, hot-spot manifolds and modern carburetor developments are considered in a thorough manner. Methods of adjusting carburetors are fully discussed, as well as suggestions for securing maximum fuel economy and obtaining highest engine power.

The various chapter headings are Liquid Fuel Suitable for Power; Liquid Fuel Supply Methods; Carburetor Action and Construction; Modern Gasoline Carburetors; Kerosene Carburetors; Manifolds and Carburetor Installation; Carburetor Faults, Location and Remedies. The book will be of considerable value to repair men, students and motorists.

The Starrett Book for Machinists' Apprentices.—Published by the L. S. Starrett Co., Athol, Mass. Fourth edition. One hundred and seventy-six 4½ x 7-in. pages. Price, 50 cents.

The book, now in its thirty-fifth thousand, is well illustrated and designed to answer in an authoritative manner questions as to how to do the everyday work of the average machine shop. It is bound in red Athol leather. The different classes of work are taken up separately, the most common errors pointed out and the correct practice indicated. Much attention is given to the proper use and care of tools, the reading of micrometers and verniers, bench work, lathes and lathe tools, grinding, bolts, gears, etc. The book is essentially for the apprentice rather than for the expert machinist, though the latter will find much of interest and value, and is intended to provide the answers to the many questions usually asked of the foreman or superintendent. Distribution is being made exclusively through the hardware dealers handling the Starrett line of tools.

Johnson's Materials of Construction.—Fifth edition, rewritten by M. O. Withey and James Aston; edited by F. E. Turneaure. Eight hundred and forty 6 x 9-in. pages; fully illustrated; bound in heavy red cloth boards. Published by John Wiley & Sons, Inc., New York. Price, $6.

This is a revised, rewritten and enlarged edition of the book originally compiled by the late J. B. Johnson, dean of the College of Engineering of the University of Wisconsin. Two of the present editors are connected with the same university, while Mr. Aston is metallurgist for the A. M. Byers Co., Pittsburgh, Penn.

The book contains an enormous amount of information of value to anyone interested in the various materials of construction. It is intended both as a text and a reference book, and in arrangement it differs markedly from the former work, which was somewhat cumbersome. The division into parts has been discarded and the related subject matter has been more closely coördinated. This is a great improvement. The various chapter headings are: Synopsis of the Principles of Mechanics of Materials; Machines and Appliances for Mechanical Tests; The Mechanical Testing of Structural Materials; Characteristics, Physical Properties and Uses of Wood; The Deterioration and Preservation of Timber; The Mechanical Properties of Timber; Building Stone; Structural Clay Products; Portland Cement; Natural and Other Hydraulic Cements; Limes and Plasters; Methods of Testing Hydraulic Cements; Making Mortar and Concrete; The Physical Properties of Mortar and Concrete; Portland Cement Products; Metals and Their Ores; Manufacture of Wrought Iron and Steel; The Manufacture of Iron and Steel Shapes; Formation and Structure of Alloys; Constitution of Iron and Steel; Properties of Wrought Iron; Properties of Steel; Alloy Steels; Cast Iron and Malleable Cast Iron; Nonferrous Metals and Alloys; The Effect of Temperature on the Mechanical Properties of Metals; Fatigue of Metals; The Corrosion of Metals.

Man to Man: The Story of Industrial Democracy.—By John Leitch. Two hundred and fifty 5 x 7¼ pages. B. C. Forbes Company, 299 Broadway, New York. Price, $2.

The author directs the reader's attention to the condition of industrial unrest which because of the changing status of industry itself and the constantly increasing cost of living has become more and more in evidence for the past decade and which greatly intensified by the events of the past two years imperatively demands remedial action. Ten years ago Mr. Leitch, himself a workman in the Chicago stockyards, realizing that something must be done to meet the condition which even then assumed an ominous aspect, set himself to study the causes with a view to applying the remedy.

He explains that industrial democracy did not come full fledged into being, but was evolved through years of experiment based on the fundamental principle of justice between employer and employee. Its machinery, which is modeled after the legislative machinery of our federal Government, provides the means of communication by which the opposed ends of the industrial organization may get together, learn each other's trials and limitations and cease to be opposed—to become one single unit working in harmony and coöperation toward the definite end of mutual advancement

Four chapters are devoted to the citation of the workings of the system as installed in industrial establishments, varying from velvet mills to iron foundries, and show that in all cases where it has been put into practice it has had the effect of increasing production and profits while at the same time it increased the financial return to the employees, eliminated the spirit of unrest and antagonism and substituted a feeling of mutual confidence, respect and good-will.

By no means the least of the virtues claimed for Industrial Democracy is that the practical application of its principles teaches the employee Americanism, helps him to understand his relation to his government, and in the case of the foreign-born worker it discourages the tendency to segregation that has become a serious menace to peace and prosperity.

Forthcoming Meetings

American Association of Engineers. Annual meeting has been scheduled for May 13 at Chicago.

American Society of Mechanical Engineers. Spring meeting to be held at Hotel Statler, Detroit, Mich., June 16-19, 1919. Secretary, Calvin Rice, 29 West 39th St., New York City.

American Supply and Machinery Manufacturers' Association. They will hold a convention in Pittsburgh, Mar. 14-16. W. G. Clyde, general manager of sales for the Carnegie Steel Co. is general chairman.

American Society for Testing Materials. The 22nd annual meeting of the society will be held at Atlantic City, N. J. on June 24-27, 1919, with headquarters at the Hotel Traymore. Alfred D. Flinn, secretary, 29 West 39th St., New York.

Boston Branch National Metal Trades Association. Monthly meeting on first Wednesday of each month. Young's Hotel. Donald H. C. Tullock, Jr., secretary. Room 41, 166 Devonshire St., Boston, Mass.

Engineers' Club of Philadelphia will hold its regular meeting at Witherspoon Hall, Tuesday evening, April 15, 1919. Announcement has been made of a special meeting on Apr. 23, at which Arthur J. Baldwin, vice president of the McGraw-Hill Co., Inc., will speak.

Engineers' Society of Western Pennsylvania. Monthly meeting, third Tuesday; section meeting, first Tuesday. Elmer K. Hiles, secretary, Oliver Building, Pittsburgh, Penn.

National Foreign Trade Council. Annual meeting at Chicago, Apr. 24-26. O. K. Davis, secretary, 1 Hanover Square, New York.

National Machine Tool Builders' Association. Spring convention to be held at Atlantic City, N. J., May 12 and 13, with headquarters at Hotel Traymore. C. Wood Walter, Cincinnati, Ohio, secretary.

National Metal Trades' Association will hold its 21st annual convention at the Hotel Astor, New York, Apr. 23 and 24.

New England Foundrymen's Association. Regular meeting, second Wednesday of each month. Exchange Club, Boston, Mass. Fred F. Stockwell, 205 Broadway, Cambridgeport, Mass.

Philadelphia Foundrymen's Association. Meeting first Wednesday of each month. Manufacturers' Club, Philadelphia, Penn., Howard Evans, secretary, Pier 45, North Philadelphia, Penn.

Providence Engineering Society. Monthly meeting fourth Wednesday of each month. A. E. Thornley, corresponding secretary, P. O. Box 796. Providence, R. I.

Rochester Society of Technical Draftsmen. Monthly meeting, last Thursday. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester, N. Y.

Superintendents' and Foremen's Club of Cleveland. Monthly meeting, third Saturday. Philip Frankel, secretary, 310 New England Building, Cleveland, Ohio.

Technical League of America. Regular meeting, second Friday of each month. Oscar S. Teale, secretary, 240 Broadway, New York.

United States Chamber of Commerce Annual convention to be held at St. Louis Apr. 28, 29 and 30.

Western Society of Engineers, Chicago, Ill. Regular meetings, first, second, third and fourth Mondays of each month, except July and August. Edgar S. Nethercut, secretary, 1735 Monadnock Block, Chicago, Ill.